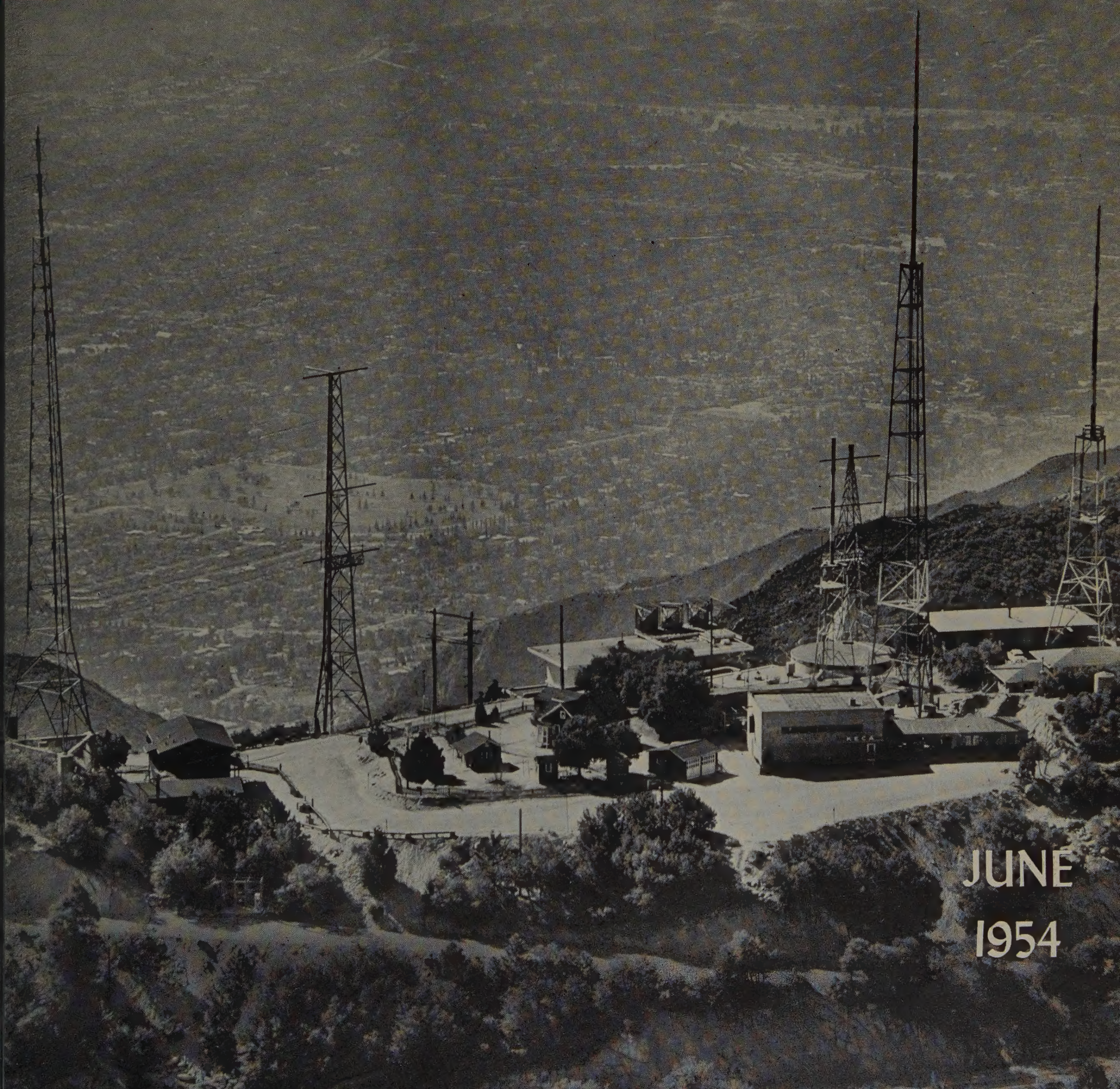
ELECTRICAL ENGINEERING



JUNE
1954

SUMMER AND PACIFIC GENERAL MEETING, LOS ANGELES, CALIF., JUNE 21–25, 1954

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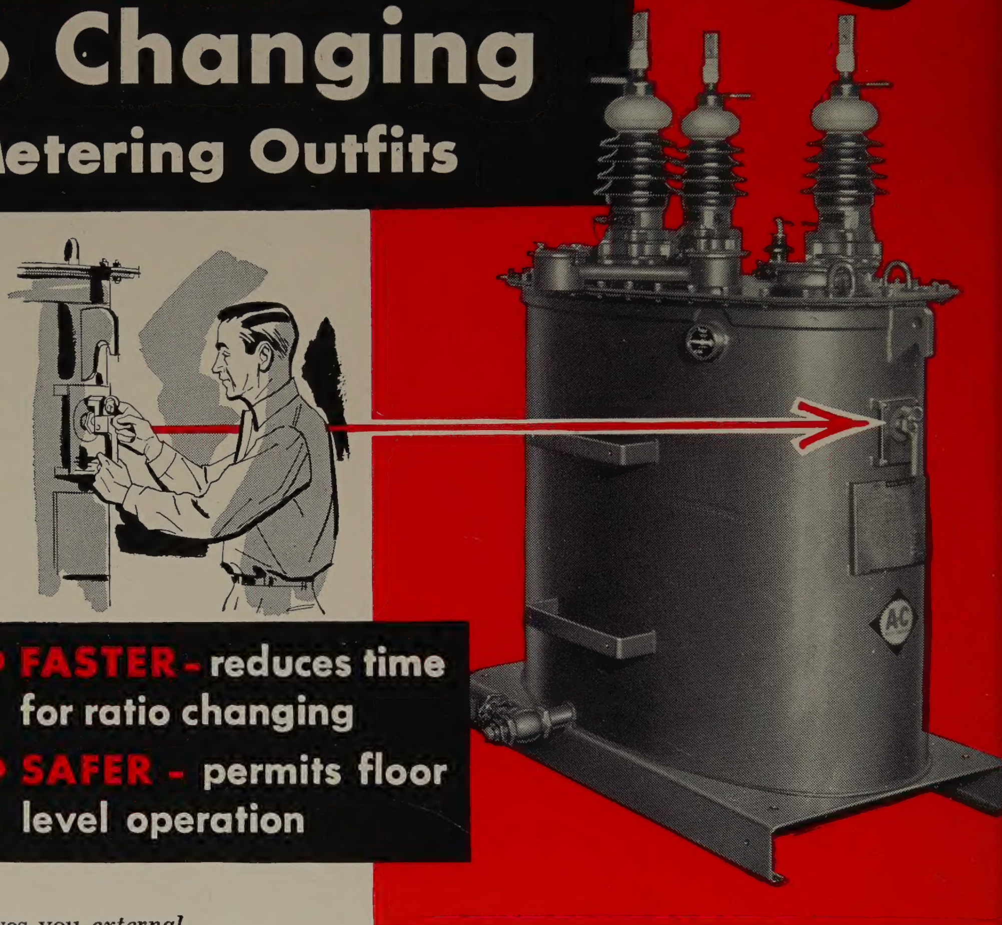

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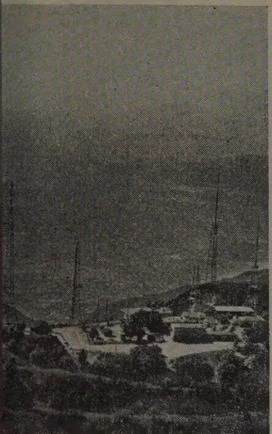

The Cover. Aerial view of Mount Wilson, subject of a Summer and Pacific Meeting inspection trip, showing a number of the Los Angeles television and FM transmitting stations and the telephone office, identified by the three horn lens antennas, through which they are served.

JUNE 1954

TECHNICAL PAPER DIGESTS

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HIGHLIGHTS ....

Ten Founding Fathers of the Electrical Science—III. Benjamin Franklin's studies and experiments established the identity of friction-produced electricity and lightning, the idea of the lightning rod, and the single-fluid theory of electricity. His observations on charged bodies and capacitors and his famous kite experiment to confirm the electrical nature of lightning are described (*pages 506–07*).

Secretary Henline Retires. After 27 years' service on the Institute staff, Secretary H. H. Henline retires June 1, 1954. Serving first as Assistant National Secretary, he became Acting National Secretary in 1932 and was appointed National Secretary in 1933. Mr. Henline's contributions to Institute growth in membership and his leadership in expanding the technical activities and publications of the AIEE are discussed (*pages 487–8*).

Creative Thinking in Scientific Work. Each person who attempts to train himself to think creatively should be familiar with the processes of this type of thinking as well as the guideposts and road blocks. An analysis of how this will help will be found in this issue (*pages 489–94*).

Engineering Profession Comes of Age. During the past 25 years engineering registration laws have been enacted throughout the United States. Engineers now are working toward improved and uniform legislation but if their efforts are to be effective, they must have the backing of a co-ordinated engineering profession. When this has been achieved, then the profession can be said to have come of age (*pages 495–6*).

Development of Nuclear Power for Peaceful Purposes. For several years engineers have been considering the generation of power by nuclear reactors. Dr. Smyth discusses the different types of reactors, their operation, and a 5-year program (*pages 498–503*).

Ventilation of Inner-Cooled Generators. Inner-cooling of turbine-generator rotor and stator windings permits the building of machines of high specific ratings with moderate hydrogen pressures. Additional improvements in blowers, coolers, seals, and ventilation arrangements increase the efficiency and compactness, while the outer details of the turbine-generator unit result in a pleasing over-all appearance (*pages 508–13*).

Research for and by the Electric Power Industry. While lauding its past performance, it is held that the electrical utilities should undertake both scientific and economic research financed by an industry-wide budget for joint co-operative research. It is suggested such a program would do much to maintain and improve the industry's competitive position, reduce costs, aid in building loads, provide a basis for adequate forecasting, and meet its public responsibilities (*pages 516–21*).

The Electroluminescent Lamp. A comprehensive summary of the technical information available on this new light source is presented which includes the basic principles, optical characteristics, the mechanism of electroluminescence, electrical properties of the lamp, and applications (*pages 524–8*).

Performance Specifications Are Needed for Electronic Control. The user of an electronic-control device needs specifications so he will know if he gets the right apparatus to perform the required function; the device's manufacturer must have these specifications so he will know what he must build into it. These important factors are considered in this article (*pages 532–5*).

Long-Time Scale Models of Transformers for the Determination of Transient Voltages. In electromagnetic models, developed to furnish directly all answers required for transformer design and development, all points of interest are readily available—many more so than in the original model—and all types of impulse waves, connections, and terminations are produced readily. The long-time scale model, the slow-speed transient analyzer, a comparison of transient voltages in the model and the original, typical presentation of design information with a long-time scale model of a large 3-phase power transformer, and applications of the electromagnetic model are discussed (*pages 543–7*).

The Bewildering Decibel. A critical review of the various quantities which have been held to be decibels is presented as well as an examination of the properties of factors associated with them. On the foundation thus laid a specific proposal is made for dealing with these quantities in a convenient and ordered fashion (*pages 550–5*).

Industry Co-ordination of Microwave Communications Systems. A discussion of problems concerned with co-ordinating microwave systems in safety and special services in order to obtain maximum use of the spectrum (*pages 537–40*).

Temperature Classification of Insulating Materials. Many new insulating materials have increased temperature resistance and better resistance to oxidation and are finding important applications in electric apparatus. The rules of AIEE Standard No. 1 no longer meet the industry's needs and so a new one, on a trial basis, has been issued (*pages 548–9*).

News Index

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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Secretary Henline Retires June 1 After 27 Years of Service

HENRY HARRISON HENLINE (AM '19, M '26 F '43) retires from the AIEE secretaryship on June 1, 1954. He joined the staff of the Institute in January 1927 after many years of active work with the Stanford University Branch (Counsellor, 1926), the San Francisco Section (Chairman, 1922–23), and the Pacific District (Chairman Student Activities Committee, 1926). Joining the staff as Assistant National Secretary, his first work assignment was to develop further the Student Branches and Sections which at that time were showing the first evidences of the tremendous future development.

On the death of F. L. Hutchinson in 1932, Mr. Henline was appointed Acting National Secretary, and, effective January 1, 1933, he was appointed National Secretary in which capacity he has continued ever since. Subsequently the title was changed to Secretary because of the international scope of the organization. Mr. Henline's period of administration was a remarkable one for the way in which he brought the Institute through the depression of the Thirties and the World War II years.

SECTIONS, BRANCHES, AND MEETINGS

THE number of Sections has almost doubled, 52 in 1927 to 100 today. In the same period, the Branches increased from 95 to 135 and the student enrollment from 3,300 to 6,800. His feeling of pride can well be imagined when in 1950, because of the return of the veterans, student enrollment reached the unprecedented and unduplicated peak of 20,668.

In 1927, three national conventions and four District meetings were held at which a total of 144 papers and 15 technical committee reports were presented. In 1953 four General meetings, three District meetings, and 15 special technical conferences were held at which over 1,100 papers were presented.

MEMBERSHIP AND FINANCE

THE membership as of April 30, 1927, was 18,344, whereas today it is over 47,000, or more than a $2^1/_2$-fold increase. The membership declined in 1935 as a result of the depression to a low of 14,269 but has since increased steadily and since 1937 AIEE has been the largest of the four Founder Societies. The number of members on the headquarters' staff has increased from 32 in 1927 to a total of 63. On the financial side, an analysis of the auditors' report for the year ending April 30, 1927, shows that the Institute's surplus, property fund reserves and restricted fund reserves, was $729,361; whereas for the year ending April 30, 1953, it was $1,314,094. Resourcefulness in carrying out Institute policies on his part and his counsel and guidance on many occasions have contributed to the Institute's strong financial position.

INCREASED TECHNICAL ACTIVITIES

IF ANY particular activity can be singled out, however, Mr. Henline's long continuing devotion to the technical work of the Institute has earned for him the gratitude of the profession. Long before opinion polls showed that the membership overwhelmingly supported the technical operations of the Institute as being of primary importance, Mr. Henline took every opportunity to improve and consolidate technical committee and staff organization concerned with this phase of the Institute's activities. Serving as secretary of the Planning and Co-ordination Committee since his assumption of the secretaryship of the Institute in 1932, he was able with each succeeding ad-

Secretary Henline (right) greets his successor N. S. Hibshman

ministration to contribute of both his background knowledge and his personal forceful opinions for the betterment of the Institute's engineering work.

As a result of studies, the technical committee organization was greatly expanded and organized in five broad technical divisions: communication, general applications, industry, power, and science and electronics; with a divisional committee at the head of each division. The Committee on Technical Operations was established through a combination of the Technical Program and Technical Advisory Committees. In January 1927, there were 16 technical committees including the Committees on Research and Education, which are now general committees; whereas under the expanded technical committee organization today, there are 40 technical committees.

In 1947, the Fall General Meeting was established to provide for the presentation of more papers in the Middle West. In 1948, special technical conferences were inaugurated; these are devoted to specialized subjects and usually held in the regions where the industries concerned with the subject matter are concentrated.

EXPANSION OF PUBLICATIONS

In 1931, the name of the *Journal* was changed to *Electrical Engineering* and the contents were broadened. In 1947, the *Transactions* section of *Electrical Engineering* was discontinued and the papers from that section were issued as individual pamphlet copies collated with discussions and known as AIEE *Proceedings*. The contents of the magazine were still further broadened.

In relation to the organization of the technical committees in five broad divisions, three new bimonthly publications were inaugurated in July 1952: *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems* to supersede the *Proceedings*. Members may receive one of these three publications without charge and they can subscribe to the others. The bimonthly publications provide a quick medium of obtaining the *Transactions* papers without the necessity of ordering and they have met with popular response by steadily increasing circulations. The annual *Transactions* is published in three parts corresponding to the bimonthly publications.

As indicative of the expansion in publications, volume 26 of the 1927 *Transactions* contained 120 papers and reports in 1,178 pages. Volume 72 of the 1953 *Transactions* in three parts contained a total of 388 papers in 2,720 pages. In all of its publications, the Institute publishes more than 600 different articles and papers a year.

As Mr. Henline has served on both the Planning and Co-ordination Committee and the Publication Committee since 1932, his knowledge and understanding of Institute problems from long experience and his administration of the headquarters' staff made possible the molding and carrying out of these policies.

STANDARDS

In 1927 there were about 30 standards and specifications which had been issued by the Standards Committee, 16 of which had been approved by the American Standards Association (ASA). Today approximately 70 standards, test codes, and reports are distributed by the Institute as AIEE Standards or as American Standards in which the Institute has co-operated in their formulation. A number of others have been formulated through Institute representatives and many of the ASA sectional committees.

BIOGRAPHICAL

Mr. Henline was born March 12, 1889, at Colfax, Ill., and was graduated from the University of Illinois in 1914 with a bachelor of science degree in electrical engineering. After serving for a year as instructor in science and mathematics in the Oktaha (Okla.) High School and as director of athletics for the public schools there, he entered the Chicago Central Station Institute of the Commonwealth Edison Company. In 1916 he entered the commercial engineering department of the Illinois Maintenance Company, Chicago. Joining the faculty of Stanford University in 1917 as an instructor, Mr. Henline was promoted to assistant professor and to associate professor.

Mr. Henline has served on the following Institute committees: Sections (1923–27, 1934–35); Education (1929–36); Co-ordination of Institute Activities (1932–38); Planning and Co-ordination (1938–54); Edison Medal (1932–50); Headquarters (1932–52); Publication (1932–50); Public Relations (1948–51); Special Committee on Institute Policies (1932–33); Special Committee on Foreign Applications (1930–31); Special Committee on Election Procedure (1934–36); Joint Committee on State Councils of Professional Engineers (1932–34); and on the Board of Trustees of the Retirement System of the AIEE (1943–53). He has served as Institute representative on the American Year Book Advisory Board (1927–54); American Standards Association, Alternate (1929–33, 1938–41); American Engineering Council (1932–33, Alternate, 1934–40); Engineering Index Advisory Board (1928–34); National Research Council, Engineering Division (1932–39); Library Board, United Engineering Trustees, Inc. (1932–48); Engineers Joint Council Committee on International Relations (1952–54); Conference of Representatives from Engineering Societies in Western Europe and the United States (1951–54); and Construction Industry Advisory Council (Oct. 1951–54).

The Institute is fortunate to have obtained an excellent successor to Mr. Henline. On April 7, the Board of Directors elected Nelson S. Hibshman (AM '27, M '32, F '41) to be Secretary of the Institute effective May 1, 1954. Mr. Hibshman is well versed in Institute affairs having served as Counselor of the Lehigh University Branch and as Chairman of the Lehigh Valley Section. He also has been on a number of committees for a period of years and was Assistant Secretary since January 1953. He previously served on the Board of Directors, as Vice-President of the Middle Eastern District from 1941–42, and as Treasurer in 1952. Formerly he was head of the Electrical Engineering Department at New York University from 1942–44, and dean, School of Engineering, Pratt Institute from 1944–53. A more complete biography of Mr. Hibshman was published in *Electrical Engineering* for December 1952, page 1150.

Creative Thinking in Scientific Work

E. I. GREEN
FELLOW AIEE

Creative thinking can be approached in somewhat the same way as a technical subject and the ability to think creatively may be acquired to a considerable extent. The characteristics, types, and processes of creative thinking are discussed.

DESPITE THE biblical adage, man by taking thought already has added not a few cubits to his stature, and bids fair to add many more. The dominant effect of scientific advance in shaping man's progress, his customs, and his destiny, long since has become axiomatic. Everyone knows, too, that advances in science and technology are begotten of creative thinking on the part of scientists, engineers, and inventors. "Human thought," said Daniel Webster, "is the process by which human ends are ultimately answered." It follows that no small moment attaches to understanding as far as possible the processes of creative thought, and to finding and utilizing ways of stimulating and directing them. Of course, this is an imprecise and intangible subject. In this psychological domain the scientific method is as yet difficult to apply. Perfectly ordered engineering solutions are not to be expected. Nevertheless the importance of the matter justifies sober study. Fortunately, it seems to be true that creative thinking can be approached in somewhat the same way as a technical subject, and that the ability to think creatively is not wholly innate, but may be acquired in considerable measure. It is with these aspects of creativity, especially as appertaining to scientific work, that this article is especially concerned.

DEFINITIONS

FIRST, the semantics need to be settled. What is creative thinking? The suggested definition is merely this: "Creative thinking is the bringing of something new into being through a process of thought." The "something new" may assume many different forms. It may be a musical composition, or a painting, or a poem, or a business plan. It may be a new process, machine, manufacture, or composition of matter, as these concepts are understood in the patent laws. It may be a new device, a new scientific principle, a new mathematical theory. Or it may be a new transistor circuit, or an equalizer design, or a piece of equipment, or a plan for a new system, or a technical memorandum, or an article for publication.

It will be observed at once that there are many processes of thought which are not comprehended within this definition of creative thinking. When a person reads a book for example, he may engage in a lot of cogitation, but usually it does not reach the stage of creative thinking. To take another example, a person who works a cross-word puzzle may think hard, but he does not qualify under the definition.

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In technical circles, creativity as here defined goes beyond the process of analysis by logic or experiment, and requires that something new be added. Moreover, this discussion, for practical reasons, will be even more circumscribed than the foregoing definition requires. Pleasant as it might be to discourse on creative thinking in the arts, or even in the business world, consideration will be directed largely toward creative thinking along scientific lines.

On the other hand, attention is called to the fact that the field to be covered is extremely broad. In particular, the definition goes far beyond patentable invention. The fact is that a large part of creative thinking in scientific work does not involve patentable subject matter.

Above all, it must be clear that creative thinking connotes much more than the flash of genius—the lightning stroke in which Newton discovers the law of gravity or Darwin conceives the theory of evolution. The flash of genius may be incredibly spectacular. Beyond doubt it plays a large part in scientific advance. Also there is little question that, with proper understanding of the factors involved, the probability of its incidence can be materially increased. Nevertheless, it seems fair to say that the flash of genius has been overemphasized, and that it is more important to understand and practice that systematic scientific thinking which leads to ordered progress. Furthermore, sudden insight seems most likely to occur when preceded by methodical thinking. So the thesis is offered that these two scientific flora can be cultivated in symbiotic association.

OBJECTIVES

WITH TERMS defined, the next step is to specify the objectives of this study. To begin with, certain intentions may be disavowed. The role of genius in creative thinking is not going to be stressed. This has been overdone by those writers who specialize in dramatizing science for the layman. In describing the industrial research and development laboratories which constitute a new and major element in the advance of science today, the popular way is to depict houses of magic where gifted individual geniuses rub Aladdin's lamps to summon new jinni to produce new marvels. Such allegories, while entertaining, give a distorted picture of the co-ordinated effort whereby experts seek out new knowledge and develop new applications thereof.

Neither will the history of creative thinking be reviewed, nor classical examples be examined and admired. The profusion of material along these lines is left to the reader

for his leisure hours. An important aim, however, will be to provoke more curiosity about creative thinking and more study of existing literature on the subject. To this end references are appended[1–8] in which many of the ideas presented herein are unfolded, as well as a lot of others. Several of the references include bibliographies, so that the reader can carry on from there to his heart's content.

Yet another objective will be to discover what characteristics or aptitudes of an individual play a part in creative thought, with the hope that this may facilitate the recognition and stimulation of useful traits, both by the individual himself and also by others concerned with his achievements.

A further purpose is to analyze the types and processes of creative thought, and to develop some conviction that effective mechanisms are not esoteric, but are sufficiently well known so that a person can train himself for greater proficiency in the art.

Finally, some practical suggestions in regard to creative thinking will be offered. This is done with no little diffidence, and with no pretense on the part of the author that his practice conforms to his preachments. Let it be noted, however, that genius is a proverbially poor tutor, and that the imperfect practitioner of an art usually imparts it the best.

CHARACTERISTICS

At this juncture the reader may ask: "What manner of person is a creative thinker?" Unfortunately the answer is that no two creative thinkers are alike. Each one has his own capabilities, his own methods, his own idiosyncrasies. Notwithstanding this, a number of writers have concluded that two general types can be distinguished: the intuitive thinkers and the logical ones—the people who conceive a new idea and then test it, and the people who accumulate knowledge and analyze it until something new emerges. Considerable emphasis has been laid on these two types. The evidence indicates, however, that these are the extremes, and that most creative thinkers are mixtures of the two. It is suggested, therefore, that would-be creative thinkers exploit both approaches to the maximum extent possible.

To delve deeper into the characteristics of the creative thinker, attention is called next to a study carried out by Donald Walker at the University of Chicago. He devised tests for measuring five specific aptitudes which he felt might be essential to creative thinking, and applied these tests to a large group of chemists and mathematicians noted for their original contributions. Here are the aptitudes and the scores:

Ability	Approximate Percentage With High Score
Originality of response	28
Sensitivity to environment	22
Copious flow of ideas	33
Flexibility of approach	55
Ability to concentrate	39

Walker found that incidence of all five abilities in a single individual was extremely rare. He concluded that the best way to obtain creativity is not to depend on isolated original thinkers, but to assemble a group of individuals whose talents in these five areas are complementary, and train them for teamwork.

This analysis, while enlightening, leaves us wondering whether any more basic capabilities or propensities can be found in the make-up of the creative thinker. Search of the literature reveals a confusing array of such factors. Those which have appealed to the writer as being most important follow.

To begin with, there is *knowledge.* Wisdom is the foundation of new ideas, and a certain threshold level of acquaintance with the subject is practically essential for creative thought.

In part the necessary knowledge may be acquired through formal training. It seems to be true, however, that creative thinkers almost invariably possess an uncommon *capacity for self-instruction.*

Another cardinal requirement is *curiosity.* This refers, of course, not to a meddling interest in the affairs of others, but to scientific curiosity, that insatiable hunger to know how and why. This may well be the most valuable trait that a scientist can have.

Next should be set down *observation.* This is somewhat the same as Walker's "sensitivity to environment." In particular, the creative thinker should be ever on the alert for exceptions, anomalies, and the like. A new uncertainty is apt to be more useful than an ancient verity.

Not far behind comes *memory.* Since creative thinking is frequently nothing more than the bringing together of factors never before associated, the recollection of past observations and previous ideas may play a large part. Storing up old or unused ideas in the garret of the mind is a profitable habit.

Many writers say that *intellectual integrity* is the first quality of the scientific mind. In the words of Michael Faraday, the creative thinker should be "a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature."

Allied to integrity is the next factor, *skepticism.* However he may behave in private life, the creative thinker, in his technical world, must woo the unconventional. He must be an iconoclast, a breaker of idols, a discarder of trammels.

Nor should *imagination* be forgotten. On this there is unanimous agreement among accepted authorities. But it is rather difficult to define as a trait. Maybe it is not too different from Walker's "copious flow of ideas."

Perhaps *enthusiasm* should have had a higher place on the list. Creative thinking is seldom a process of the intellect alone. For maximum achievement, the mind must be inspired by the driving power of the emotions.

Coupled to this is *persistence*—the stubborn will to solve the problem despite maddening difficulties and frustrations.

This is the quality which stands out in the records of creative thinkers, and the one which they themselves reiterate when counseling those who aspire to follow in their footsteps.

This brings the list of characteristics to ten, which seems a good place to stop. Though the list is impressive, no one should be frightened by it. Under no circumstance should anyone conclude that every creative thinker must embody an extreme measure of each one of these characteristics. If their presence in recognized creative thinkers could be determined, they surely would be found to occur in widely varying degree. So they should be regarded as desirable rather than essential qualities.

At this point someone may ask, "Are not these characteristics inherent; are not creative thinkers born, not made?" The answer is: "To some extent, yes," but with the quickly added assertion that most people who have chosen science as their life work do in fact possess a fair measure of the characteristics named, and the further thesis that latent powers of this kind can be developed and stimulated. Notable in the latter connection is the program of instruction in creative engineering which is being conducted at Massachusetts Institute of Technology by Professor J. E. Arnold and others.[9]

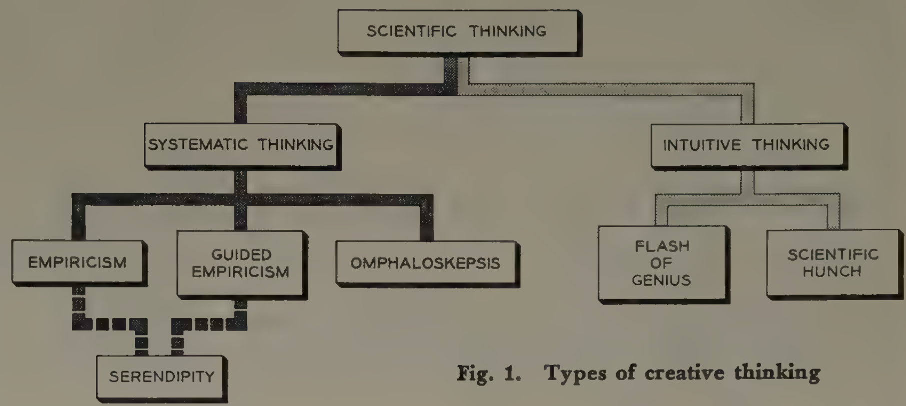

Fig. 1. Types of creative thinking

TYPES OF CREATIVE THINKING

Next it is in order to consider the different types of creative thinking. Since each writer has a different classification, the author claims the privilege of devising his own. Like all the others, it is rather loose. To simplify things, it is put in the form of a family tree. See Fig. 1.

At the opposite ends of what is conceived to be a continuum of creative thought, lie *systematic thinking* on the one hand, and *intuitive thinking* on the other. The one is the deliberate act of the conscious mind, the other the gracious gift of the subconscious in return for the previous labors of the conscious mind.

To take intuitive thinking first, it has its spectacular form, the flash of genius, the sudden brilliant answer to a baffling problem. It has also its less pretentious form, which is herein termed the scientific hunch.

Systematic thinking presents a greater diversity. There is, first, the pursuit of new knowledge by observation and experiment alone, without recourse to theory. This form was pursued so assiduously by Thomas Edison that it often bears his name; a better name, however, is *empiricism*, from the Greek "en peira," meaning "by trial."

Opposed to empiricism is the purely rational approach through formulation of theory. A British officer in India devised a delightful name for this process. He called it "*omphaloskepsis*," meaning deep meditation, in oriental fashion, while gazing at the navel. The occidental style of gazing at feet on a desk is capable of producing a similar effect. Of course the scientific method requires that any conclusions arrived at by either process be subjected to experimental verification.

In between empiricism and omphaloskepsis, lies the invaluable hybrid combination of *guided empiricism*. Finally, there is one offshoot of experimentation, whose name derives from a fairy story about the three Princes of Serendip (the old name for the island of Ceylon). These princes had the happy faculty of discovering something valuable by accident while searching for something else. To describe this gift, which is exemplified again and again in the annals of science, Horace Walpole coined the word *serendipity*.

A classic example of serendipity was the accident which led Dr. Alexander Fleming to the discovery of penicillin. While Fleming was studying new strains of bacteria, a culture plate which he had prepared became contaminated with a blue-green mold, penicillium notatum. He observed that the plate was covered with colonies of bacteria except for a clear space surrounding each spot of mold. The idea occurred to him that the mold produced something which interfered with multiplication of bacteria, and he went on with research which resulted in isolating penicillin. It is noteworthy that serendipity alone did not achieve the result, but was merely the starting point of a chain of creative thinking.

PROCESSES

If the types of creative thought are difficult to analyze, the processes are more so. People are different; thought patterns are polymorphic. Whereas a number of types and blends of creative thinking were noted, the processes are even more numerous and varied. The one which has been studied the most is the flash of genius, so perhaps that is the place to start. In the literature on this subject, records of famous thinkers and inventors throughout history have been examined under high magnification. Contemporary thinkers have been analyzed and dissected by means of questionnaires. Out of all this has come a fairly clear picture of the steps or stages which can be distinguished in the flash-of-genius phenomenon. See Fig. 2.

First comes the *conception of the problem* or perception of the need. This may occur in various ways. Frequently, it may be merely the realization or formulation of a need or problem of long standing. Back in the mid-20's many persons were aware of the necessity for a far better ampli-

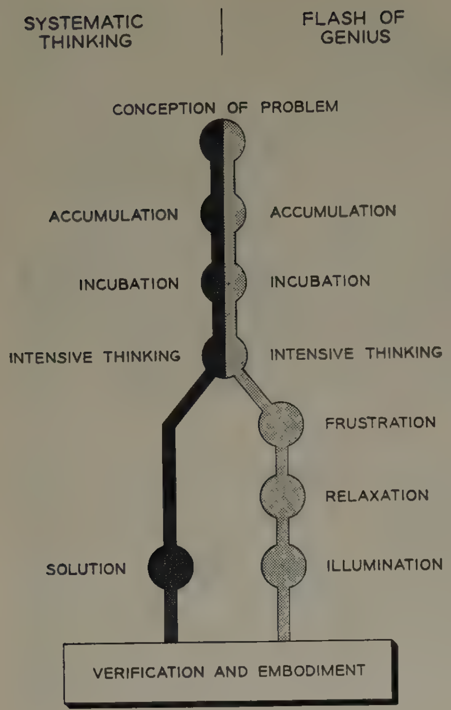

Fig. 2. Processes of creative thought

fier characteristic in order to achieve far-flung multichannel communication systems with great numbers of amplifiers in tandem. Harold S. Black stripped the problem down to the fundamental one of an amplifier output having an unwanted component not present in the input. This was the preliminary to years of study and approaches, out of which came the bold conception of an amplifier with large negative feedback, providing a new order of performance and bringing the problem of amplifier distortion within bounds.

Often the problem or need is thrust upon a person by the requirements of his job. But sometimes the genesis of the problem occurs in a flash of illumination which stems out of familiarity with an area of knowledge. Such an illumination of the problem, indeed, may be akin to the flash which later solves it.

The next stage is one of preparation or *accumulation*. The problem is investigated in all directions—by reading, by discussion with others, by experiment if need be.

Frequently there will follow a period of *incubation* in which the mind digests and assimilates the information previously acquired. Some of this mental action may be subconscious.

Next comes the stage of deliberate, *intensive thinking* about the problem. Attempts are made to solve the problem by weaving ideas into new combinations. The reaches of memory are called upon. Reasoning is used to control the thought patterns, and judgment to determine their validity.

In the typical flash-of-genius case, there is a succession of trial solutions, each one bumping a dead end. Finally, the thinker runs out of ideas. He keeps on churning the old ones round and round, and winds up in a stage of *frustration*. It would even appear that a high degree of frustration may help to engender the subsequent revelation.

Usually there ensues a time of *relaxation* of mental tensions, a period when the problem is turned over to the subconscious. On some occasion when the mind is free of obstructing interests, and concentrated attention has been succeeded by inattention or dispersed attention, the moment of *revelation* arrives. This is apt to be when the person is concerned with nothing of importance, when taking a walk, or riding on a train, or listening to music, or just letting his thoughts wander. Holidays and vacations are likely times. (It was while on vacation that J. R. Carson invented single-sideband transmission which underlies efficient utilization of the frequency band in multichannel telephone systems.) Often the insight takes place near the fringe of consciousness, just before going to sleep, or just after waking up. Just what actually happens inside the cranium when the flash of genius occurs, is not definitely known. But at least enough is known to set the stage for the dramatic episode. Whatever the mechanism, the occasion for the revelation is the interval of calm following a period of intense and fruitless speculation which somehow conditions the subconscious channels.

Almost never is the flash of genius enough. Once in a blue moon the solution springs forth, like Minerva from the head of Jove, perfect in every detail. Even then it must be committed to paper. But far more often the flash gives an imperfect solution, or just a new start. In any case there are stern tasks to follow—days or weeks or months of confirmation by analysis or experiment, and of hammering the basic conception into practical form. This is the stage of *verification and embodiment*.

In the foregoing, the various stages which precede the flash of genius have been described as discrete entities. It will be understood, however, that in specific instances they may overlap, or become telescoped, or some indeed may be absent altogether.

Next come those minor manifestations of illumination referred to as scientific hunches. These follow a less formal procedure. They are bread-and-butter things. They may occur at any time in the course of work, if pauses are made occasionally for a broad view of the situation.

Now consider deliberate or systematic thinking. In reviewing the flash-of-genius procedure (see Fig. 2), it becomes apparent that the first four stages are, in fact, processes of deliberate thinking. These steps, namely, (1) conception of the problem, (2) accumulation of information, (3) incubation, and (4) intensive thinking, are the ones normally used in solving problems. Of course the pattern may vary. Steps may be combined or repeated. There may be additional steps of refinement, improvement, correction, or extension. The real point is that, no matter how the answer is to come, a person starts out the same way. Usually deliberate thinking does the job. Once in a long while revelation does.

GUIDEPOSTS

No doubt what the reader wants now is a set of rules of procedure for creative thinkers, a map which will enable him to reach the desired destination. Sad to say, the best that can be done is to indicate a few guideposts and a few road blocks. Each person must find his own way.

The first and most important guidepost is to *get the problem.* This does not sound very hard. Usually the scientific worker is besieged by problems. The difficulty more often lies in selecting the important problems and prosecuting these without neglect of day-to-day job requirements. How does a person go about this? One way which has been tried with some success is to make up a list of things needed in one's own area of work; needed systems, needed devices, needed procedures, needed inventions, needed experiments, or whatever. These needed things are kept in mind and singled out for special attention as circumstances permit.

There was a famous Chautauqua lecture which, years before the days of radio and television, Russell A. Conwell delivered to 13 million Americans. This lecture, which was called "Acres of Diamonds," told of a man who sold his farm and wandered all over the world looking for diamonds. After he had failed in his search, and died in poverty, the man who had bought the farm discovered on it a fabulous diamond mine. Just for good measure, Conwell went on to tell of other people who disposed of land rich with gold, or oil, or something, and spent their lives looking elsewhere for the thing they had abandoned. If Conwell were alive today, he surely would say that anyone in research and development work can find plenty of scientific riches in his *own back yard*, awaiting only interest and imagination. He might point out, too, that success in scientific work is not achieved in the traditional military pattern where a subordinate waits for his supervisor to assign tasks, and that maximum satisfaction accrues from solving problems of one's own devising.

After finding the problem, the next thing is to *understand the problem.* The importance of such understanding most often becomes apparent after the fact. Suppose similar or identical problems are assigned to two men. One of them looks at the requirements separately, takes some things he knows, adds some appliques or excrescences, and comes up with a Rube Goldberg solution. The other one analyzes the problem, combines functions, strips off nonessentials, and emerges with an answer that gladdens the heart. Understanding of the problem usually is facilitated by *discussion with others.* This has the further benefit of bringing in ideas from different areas. A few gifted individuals can do creative thinking by purely mathematical processes. For most persons, however, a *physical insight* into the problem is a vast assistance.

In many cases the next step will consist in *association of ideas* in new ways. Indeed some of the most striking examples of creative thought involve the finding of new relationships between known things or the finding of a new something which bears a given relationship to things already known. Poincare,[10] writing of the invention of a new class of functions, stated: "For two weeks I spent an hour or two each day at my working table, tried a great number of combinations but came to no solution. One evening, contrary to my custom, I drank some black coffee and could not sleep. Ideas crowded my mind; I felt them knocking together until two of them interlocked, making a stable combination."

So every creative thinker constantly needs to amass ideas and to seek for new combinations. Progress is made through trial associations. In dealing with a major problem, no idea should be rejected as irrelevant until it has been proved so. In particular, many ideas have been thrown on the ash heap because they did not fit a particular problem or because the means for utilizing them had not been perfected. These *rejected ideas* can become the cornerstones of new creations.

While chance may enter into creative thinking, this does not mean that the process should be haphazard. *Orderliness* is as important in tackling problems in creative thinking as in a mathematical exercise. Steps should be planned, records should be kept, and proper habits should be cultivated.

In planning excursions in creative thought, it should be borne in mind that a major instrument in scientific progress today is the organized, co-operative approach. Some ideas are small enough so that they can be worked out by one man. More often, however, a team attack is required. Usually the preferred type of *team attack* is not a regimented process, but one which affords opportunity for individual contributions, frequently of a high order. In all cases, whether it is a group problem or an individual one, a person can draw strength from his associates just as Antaeus did from Mother Earth.

Much has been written on how to create and preserve the *working mood.* It seems reasonable to say that the subject has been overstressed. The best way to get in a working mood is to pick up a pencil and put something on paper, and the best way to preserve the mood is to keep on putting things down. Moreover, writing is a help to thought. It is a good exercise to tabulate different parts of the problem, different approaches, etc.

As already noted, *relaxation* can play an important part in creative thinking. Occasional pauses during the day are valuable. Sleeping over a difficult problem is a basically sound procedure. Occasionally a longer period of relaxation is needed. But a person has to be careful. The process of relaxation is an enjoyable one, and it can be overdone. It is not too difficult to fall into what someone has termed a "plush-lined rut."

There is one important adjunct of creative thought which is seldom mentioned in the literature and which is neglected deplorably in scientific training. This is *vocabulary.* There is good evidence that most people think in words. If they do not know the words, they do not think. So the person who aspires to think creatively should expand his vocabulary in every possible way. He should make words his friends, dictionaries and glossaries a hobby.

And speaking of *hobbies*, there are several which are believed to be of value to the creative thinker. These include such things as puzzle solving, cryptography, chess, bridge, and other pursuits which require keen mental effort. This, of course, is not intended to belittle the benefits of other avocations which may contribute less directly to the development of creativity.

ROAD BLOCKS

WHAT OF the road blocks? To some extent these are apparent from what has gone before. Perhaps the

first is *limited intelluctual capacity*. Fortunately this is not beyond control. Not only can the human thinking machine be trained to work better; it has the amazing ability to train itself. Both brain and brawn develop by appropriate exercise.

Another road block is *limited knowledge*. The remedy is simple. When Alexander Graham Bell told Joseph Henry that he did not have the knowledge needed to invent the telephone, Henry replied, "Get it."

The next road block is *preconception* in its many forms. There is *wishful thinking*, that is, the ascribing to an idea or a device or a plan, especially one's own, virtues which we would like it to have, and the tendency to avoid evidence contrary to what we wish to believe. One way of lessening this tendency is by cultivating the habit of impartial use of multiple working hypotheses.[11] Another type of preconception is *false associative thinking;* to wit, the conclusion that all properties are superlative, or the reverse, merely because one is. A familiar example is the tendency of the human male to overestimate the other attributes of a beautiful girl. Also antagonistic if not fatal to creative thought is *group thinking*, that is, thinking like the crowd, which reaches its extreme form in mob psychology.

Another kind of road block is *credulity*. This in both scientific and popular circles seems to have its greatest manifestation in *dramatized thinking*, the tendency to believe that anything new and striking is good or true. Slightly less common, but equally fatal to creative thought, is the antithesis: *unacceptance of the new*. Also there is *superficiality*, which, so long as something looks good, accepts it without verification.

If from those attributes listed as desirable in a creative thinker, it were required to single out one whose absence would be the greatest handicap of all, this almost surely would be enthusiasm. *Passivity* and creative processes are never on speaking terms with one another.

In contrast with these psychological road blocks is one of another sort, the *harassment of detail* which work pressures produce. The only answer is to set aside time for occasional reflection.

It is also worth noting that the creative thinker frequently must accept resistance and *discouragement* as his lot. After all, the innovator is a sort of transgressor, and even in a progressive organization his way is sometimes hard. Unless he is willing to run the risk that his associates now and then may consider him eccentric and undependable, he had best eschew creativity.

CONCLUSION

So much, then, for the patterns and processes of creative thought, and related aids and difficulties. The factor of greatest significance is the strong evidence which exists that creativity can be enhanced alike by training and by conscious effort. And what of motivation? With science and technology so strongly in the ascendancy, some find their incentive in pride of contributions to society. Some have found it in the urge for fame or fortune. But for most creative workers the fountain spring of inspiration is the challenge of the difficult and the unknown, exciting an inner driving force that nothing short of complete solution can satisfy. The true scientist is generally content just to "walk within the veil of the temple of nature." The reward in terms of personal satisfaction is great. Dumas, the French chemist, pictured it as "the type of true happiness on earth."

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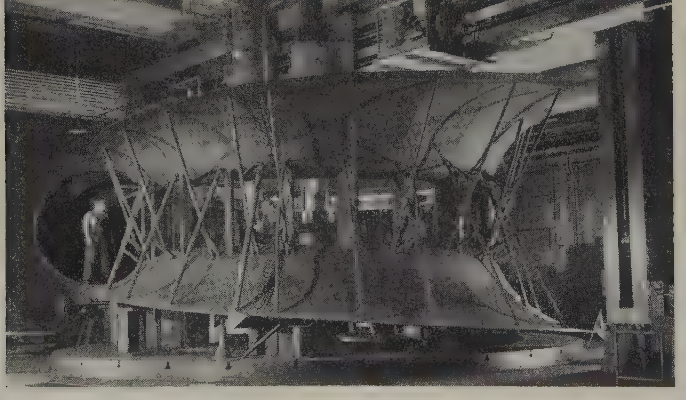
Machining Operation on Stay Ring on a Boring Mill



Carrousel-like in appearance is the machining of the inside of this cast-steel stay ring (shown in illustration at left) with attached scroll case skirts on a 40-foot mill in Allis-Chalmers shops. This machining operation could not be attempted before the inner sections of the spiral casing had been welded on because of possible warpage. The stay ring is for a 57,500-hp 112-foot-head 85.7-rpm Francis-type hydraulic turbine for the U. S. Corps of Engineers' power plant at Fort Randall, S. Dak. Allis-Chalmers is supplying this installation with eight of these turbines, the first of which was put on the line March 15, 1954. Others are being installed and manufactured.

The Engineering Profession Comes of Age

J. F. FAIRMAN
FELLOW AIEE

The engineering profession is coming of age, and one of the signs of its growing maturity has been the increasing demand for unity among engineers. In his address before a meeting of professional engineers, Mr. Fairman reiterates the importance of uniform state registration laws as a part of professional awareness.

IT IS customary on an important anniversary to look back along the road we have traveled, to size up where we are, and to survey the road that lies ahead. In this respect, I shall try to contribute a bit to our understanding of where the engineering profession came from, where it is, and where it may be headed.

In tackling an assignment of this kind there is always the temptation to minimize our shortcomings, to magnify our achievements, and to view the future optimistically. This is a characteristic common to all professional, business, political, and other organized groups of humanity. It is just a characteristic of people and, believe it or not, engineers are people.

On a similar occasion some years ago I was called upon to say a few words of tribute to a member of another group. After I had spoken and had no opportunity to answer the toastmaster, he informed the audience that I was connected with an organization which called themselves professional engineers. He allowed as how he had heard of lots of other kinds of engineers but a professional engineer was a new one to him. That incident was startling evidence of the fact that a considerable sector of the public had perhaps as little real understanding of engineers and the engineering profession as one of my great-aunts who took a very dim view of my aspiration to be an electrical engineer. She thought that meant climbing poles and felt that it was not only unduly hazardous but a decidedly undignified calling for any member of the family.

THE "PROFESSIONAL ENGINEER"

I SHALL TAKE this opportunity to answer the question because it has been asked by others and there is reason to believe it will continue to be asked. The term "professional engineer" is used in the education laws of the several states. It describes an individual who has been examined and duly certified by an agency of the state as competent to practice the profession of engineering. The simple term "engineer" which we would much prefer to use already had been used, in common usage and even in certain legislation, to designate workers in certain mechanical trades. One of the principal handicaps in the public's understanding of the engineering profession has arisen from the promiscuous use of the term "engineer" to designate such a variety of occupations as steam boiler operators, hoist operators, and locomotive drivers, as well as skilled designers and planners of structures and mechanisms, brilliant research workers, eminent consultants, and operating executives. Incidentally, for the benefit of those who still have doubts as to the necessity or desirability of engineering registration laws, I suggest that just a few months' experience as a member of the State Board of Examiners in reviewing applications for registration would serve to convince the most skeptical.

Engineering is a relatively young profession and like all young things has its growing pains. Obviously, a profession must recognize itself before it can expect to be recognized as such by the public. One of the marks of self-recognition is organization and another is the requirement for specialized training. The earliest organization of civilian engineers in this country took place and the first formal educational courses of college level were offered just a little over 100 years ago. Within a relatively short time the rapidly developing new fields of engineering resulted in the formation of additional societies each devoted to the pursuit of a specialized branch. This was natural since the primary purpose of the early societies was to develop the art and science of the several fields of interest by providing forums for the exchange of information and experience. Emphasis on specialization also resulted in the offering of more and more specialized courses of instruction by the colleges, at the expense of the humanities and even of a broad foundation in the basic sciences.

This was the period of fragmentation or subdivision of the profession which lasted nearly three quarters of the century. Then the tide began to turn.

Full text of an address presented at the Silver Anniversary dinner of the Kings County Chapter, New York State Society of Professional Engineers, March 24, 1954.

J. F. Fairman, vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y., is a past president of the Institute.

As technology became an increasingly important factor in our economy and particularly as technology began to be suspect as a contributing cause of certain new problems in society it was clear that engineers as good citizens should share the responsibility for solving those problems. This suggested the need for some additional association through which engineers regardless of their specialized interest could function in a common cause. World War I, the first war in which mechanization played a substantial part, made the engineer a more glamorous figure in the public mind. One heard a good deal about the new age of miracles in which nothing was impossible. Suddenly a lot of people wanted to be engineers. This suggested that someone ought to do something about the selection, education, training, development, and certification of engineers into the profession. In each of these situations it appeared that the engineers themselves had best be the ones to take action. Accordingly, over a period of years somewhat in excess of the 25 being celebrated here, a great many new groupings have been formed to attempt to develop one or more of these fields for the advancement of the profession and in the public interest. These efforts to work together on common problems—to emphasize the unity instead of the diversity of the profession—are evidences of growing maturity.

Let me cite a few accomplishments and suggest some opportunities for further growth:

After years of study and discussion it seems to be agreed that a better balance is needed and can be attained in the engineering colleges between sound training in basic engineering principles, an introduction to some field of specialized engineering technology, some understanding of economics and human relations so important in our complex civilization, and last but not least, the development of skill in communication, in effective writing and speaking.

Along with this, the need to prevent the waste of giving an engineering education to those who do not possess the aptitudes for it as well as the need to encourage those with the right aptitudes, is recognized and is being handled principally on an informal volunteer basis by engineers in more and more communities.

Also, the responsibility of the practicing engineer to assist in the training of young men during their postgraduate internship is being taken more seriously and is well organized in many major industrial and research organizations. More recently the development of executive talent, increasingly selected from the engineering group, is receiving special attention and is being pursued with intelligence, persistence, and sincerity. Engineers are encouraged to continue their education not only in their technical specialties but in broader fields and where no other opportunities are available the local chapters of engineering societies jointly undertake such educational programs.

SOME PROBLEMS INVOLVED

New problems will continue to arise. Two are beginning to command attention. The financial problems of our colleges and universities and the somewhat related problem of responsibility for basic research. Two solutions are being urged upon us: one, business with a capital B should pick up the check; two, government should come to the rescue. I shall not advocate either of these or any other specific solution. I shall merely point out that education and research are of vital concern to engineers as individuals and as a professional group and hence that it behooves us to do our part in helping to find the best answer. I am confident that we must and that we shall respond promptly and constructively to this new challenge.

During the last quarter century we have achieved recognized legal status in every state of the union by the enactment of engineering registration laws. It is now up to us to work for the improvement and faithful administration of those laws because they control our opportunities as practitioners and they affect the public welfare. So we are working through various channels for improved and uniform legislation and administration in the 48 states. We would be more effective if we had one organization which could be our voice before all the law-making bodies. Some of us still must learn that it is better to handle our intraprofessional problems by discussion and agreement among ourselves than to indulge in slugging matches before legislative bodies.

There are many situations of national import in which professional engineers can render disinterested public service. Legislators, administrative bodies, and, to some extent, the public are beginning to be aware of this.

Our profession has produced outstanding men whose ability and integrity are above question and who have been willing to devote time and effort toward the solution of national and regional problems.

From the point of view of professional prestige and solidarity as well as from the point of view of capturing a wide public audience it is important that these men function with the enthusiastic backing and the authority which support from a co-ordinated engineering profession can provide. An illustration of this type of voluntary public service by distinguished experts, who were members of and whose joint activity was sponsored by a number of our engineering societies, is the 1950 report of the Water Policy Panel of Engineers Joint Council, a document which had considerable influence at the right place and at the right time.

In recent years engineers have cautiously embarked upon the troubled waters where legislative bodies direct the "ship of state." We are developing our sea legs on a city, state, and national level. As we demonstrate our ability to bring sound judgment as well as technical competence to bear on difficult social and economic problems, legislators will welcome our advice more and more. There is a growing need for this type of public service. The broader our training, the greater our wisdom in human and public relations; the more coherent and authoritative the co-ordinated voice of the engineering profession, the greater will be our influence in both public and professional deliberations. That, I believe, is our profession's hope and aspiration. That will mark our coming of age.

The Magnetic Noise of Polyphase Induction Motors

P. L. ALGER
FELLOW AIEE

THE WIDE USE of induction motors in the home, the office, and the factory requires that they both look and sound well. The pleasing, if not handsome, appearance of present-day motors attests to the skill of the "appearance design" experts who have worked with motor engineers in recent years. Now, there is a growing demand that motors should have good "sonance design" also. They should give out a steady pleasing hum, just loud enough to show that they are performing their duties properly, but not loud enough to be noticed.

The magnetic field in the air gap of an induction motor creates rotating force waves with frequencies of 2 to 40 or more times the line frequency. These forces cause elliptical or nodal deformations of the motor laminations and frame, thereby producing high-frequency vibrations and "magnetic noise." Fig. 1 shows the fundamental air-gap flux wave of a motor, and its corresponding force wave, proportional at each point to the square of the flux density. Evidently, in a 60-cycle motor, this force wave, rotating with the magnetic field, produces a 120-cycle force on the stator, and corresponding elliptical core vibrations. The ear is not sensitive to 120-cycle sounds of low intensity, so that this source of noise is unimportant in ordinary induction motors. It is important, however, on large high-speed machines, especially those of 2-pole construction, and it is, therefore, customary to provide such machines with spring mountings, which isolate the core from the frame.

The principal source of magnetic noise for usual induction motors is the tooth-frequency ripple in the flux wave, indicated by Fig. 2, which gives rise to three distinct force waves, whose frequencies for a 60-cycle motor are RN, $RN-120$, and $RN+120$, where R is the number of rotor slots and N is the number of revolutions per second. For a polyphase motor with S stator slots, the numbers of cycles, or pairs of nodes, of these three principal force waves are, respectively, $R-S$, $R-S-2$(poles), and $R-S+2$ (poles). For a smooth rotor without bars or slots, $R=0$, and the magnetic forces have frequencies of $2f$, $4f$, $6f$, etc., only, corresponding to the fundamental flux wave and the magnetic saturation harmonics, if these are present.

The wave with the fewest nodes produces the largest core deflection, and, therefore, is likely to produce the most noise. Especially loud noise occurs when one of these force waves has the same frequency at operating speed as the resonant frequency of the core for the same number of nodes. Many secondary force waves are present, especially in single-phase motors, due to the interactions of mmf and saturation harmonic flux waves, which produce frequencies of RN, $RN\pm2f$, $RN\pm4f$, $RN\pm6f$, etc. When R is odd, or the motor air gap is eccentric, additional force waves with 1, 3, 5, etc., pairs of nodes are present, producing shaft vibration and magnetic noise of intermediate frequencies.

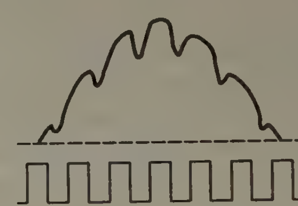


Fig. 2. Permeance ripples in air-gap magnetic field due to slot openings

Thus, the solution of the magnetic noise problem requires, first, the derivation of the entire series of air gap force waves; second, the derivation of the modes of vibration and resonant frequencies of the core; and, third, the choice of designs that will keep the force times response values small.

Magnetostriction, which is an important source of noise in transformers, is of little importance in motors. In a transformer, the flux alternates throughout the length of each leg, causing a corresponding alternating expansion and contraction of the entire core. In a motor, however, the flux density varies through a complete cycle of values around the periphery of the core, so that the net core dimensions do not change. In single-phase motors, the torque of the motor pulsates at double line frequency, due to the corresponding pulsations of the incoming power.

These several causes of magnetic noise of induction motors are now reasonably well understood, but the art of predicting the core and frame deflections that the magnetic forces cause remains quite empirical. Motors that will be satisfactorily quiet now can be produced, but how to do this most economically still presents challenging problems.

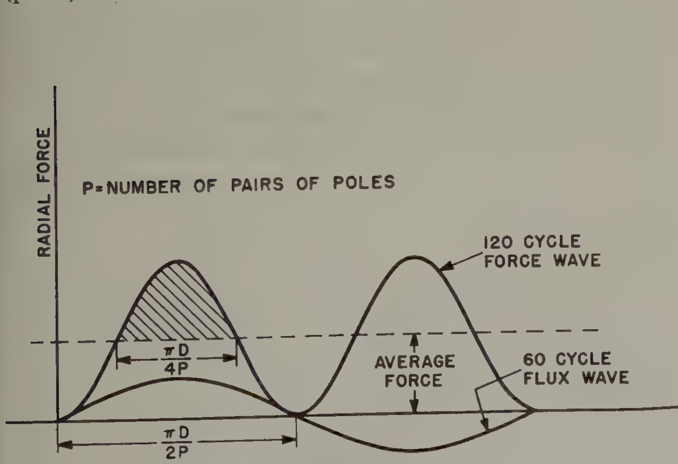


Fig. 1. Radial magnetic flux and force waves

Digest of paper 54-1, "The Magnetic Noise of Polyphase Induction Motors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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The Development of Nuclear Power for Peaceful Purposes

An Address by H. D. SMYTH

Fifteen years ago nuclear fission was discovered; 5 years later the first large nuclear reactor was started, and 5 years after that start, the Atomic Energy Commission announced its first program of nuclear reactors for power. Many problems remain to be solved, with cost among the most important.

THE STRUCTURE of modern industrial society depends on plentiful supplies of energy. There is never enough. We always are seeking new sources. Yet we have not tapped the most generous sources of energy that nature has supplied to us—the winds, the tides, the rays of the sun. We have not yet learned how to harness these great natural forces.

Fifteen years ago a new natural force was discovered, the fission of uranium. Within the first 2 months of 1939 the idea of uranium fission was suggested, communicated, proved experimentally, and published. The speed and importance of this discovery constitute one of the most spectacular events in the history of science. It involved men of many nations, free communication, high imagination, and precise experiment.

In a world at war, the potential use of nuclear fission in bombs meant that vast sums of money were soon available for its exploitation. In 1945, only 6 years later, an atomic bomb marked the end of the second World War.

We now are engaged in an effort to harness this same atomic energy for peaceful purposes. It is a great effort and indeed should be so, for success in it may change materially the lives and conditions of men. The accident of history has placed the major responsibility for this effort on the Government of the United States. As its agent, the Atomic Energy Commission (AEC) has brought together an array of scientific and engineering talent never before equalled. Private industry already is carrying a major share of our enterprise under contract to the Government and now is becoming more and more active on its own initiative. This is as it should be.

Those of us engaged in this effort believe we shall be successful. We are so confident of success that we do not begrudge the years, the skill, and the millions of dollars that are being spent to make available to man the kind of energy that heats the stars. But the road to success will be a long one. We know that it will have many dead ends, wrong turnings, and many dull, dreary stretches. The barriers to be surmounted or by-passed are formidable.

By now we think we know what these barriers are, what kinds of problems have to be solved if nuclear power is to be significant in our economy. We should know these problems, for it is now 15 years since nuclear fission was discovered, 10 years since the first large-scale nuclear reactor was started, and 5 years since the AEC announced its first program of nuclear reactors aimed at power. Energy from nuclear power plants will be just like energy from coal-burning power plants. Except for special purposes, the sole criterion of comparison will be cost.

Let me outline the problems we foresee. It is from the engineers that their solutions will come. The problems of reactor development today are explained best in terms of those which faced the designers of the first great reactors at Hanford, Wash. These problems are so fundamental that they will continue to be of major importance even though the emphasis may shift from time to time. Once I have defined the problems, I shall outline our present state of knowledge and the next major steps we are planning for their solution.

THE GENERAL PROBLEMS OF A NUCLEAR POWER REACTOR

LET ME RECALL to you the three major facts of nuclear fission. They are: first, enormous amounts of energy are released; second, the products of fission are radioactive; and third, fission is caused by neutrons and results in the production of further neutrons thereby making a chain reaction possible.

These basic facts confront the designers of reactors with a series of technical questions which can be grouped in five general areas. These general areas which have to be considered are, first of all, what we call neutron economy; second, the effects of nuclear radiations; third, heat transfer or removal; fourth, control and instrumentation; and fifth, chemical processing of fuel both before and after it goes into the reactor. Let me go into some detail about these five areas.

1. Neutron Economy. It is evident that the first requirement of a nuclear reactor is that the nuclear chain reaction shall occur. In other words, if a uranium nucleus in a structure containing uranium does undergo fission, it must produce neutrons in sufficient quantity to cause other nuclear fissions in the vicinity and to set up a self-propagating nuclear chain reaction. Actually the number of neutrons produced by a single fission is not very large. On the average, for every neutron used up in producing a fission

Complete text of an address presented at the National Meeting of the American Institute of Chemical Engineers, Washington, D. C., March 9, 1954, and recommended for publication by the AIEE Committee on Nucleonics.

H. D. Smyth is a member of the U. S. Atomic Energy Commission.

about $2^1/_2$ new neutrons are released, a net gain of $1^1/_2$ neutrons per fission. At first sight, this would appear adequate to produce a multiplication of fissions. Unfortunately, from the point of view of neutron economy, all the neutrons produced in a single fission are not absorbed in uranium 235 to produce additional fissions.

There are, in fact, four things that can happen to the neutrons that are produced in the fission process. First of all since neutrons are extremely penetrating, they simply may escape to the outside environment. A second way in which they disappear is by capture by uranium 238 without causing fission. A third possibility is that they may be captured by impurities in the uranium or by the structural materials that have to be introduced for cooling or other purposes. The fourth possible process that can occur is, of course, the capture of neutrons by uranium 235 resulting in fission. If the fourth process produces more neutrons than are lost by the first three processes, the chain reaction occurs. Otherwise, it does not. Evidently, in a given arrangement the first three processes may have such a high probability that the extra neutrons created by fission will be insufficient to keep the reaction going.

One obvious way to reduce the probability of the escape of neutrons is to increase the amount of uranium present. The more uranium there is, the more likely it is that the neutrons will be absorbed in it and cause fission rather than escape. This leads, of course, to the concept of critical mass which is familiar to many and which I will not discuss any further.

The second process we need to minimize is the capture of neutrons by uranium without producing fission. There are several things that can be done to minimize this process. Two of them depend on the great effect which the speed of the neutrons has on the probability of their absorption in uranium 238. This probability is reduced by using a slowing-down material, called a moderator, and arranging the uranium in a lattice. Another way to reduce nonfission capture by uranium is to eliminate part or all of the uranium 238 isotope, since it contributes very little to the fission process and does absorb many neutrons. Of course, in the Hanford reactors, this was not desirable because one of the objectives of the Hanford reactors was to produce plutonium by absorption of neutrons in uranium 238.

To reduce the third process, the nonfission capture of neutrons by impurities or structural materials, requires that the uranium itself be very highly purified in the first place and that structural materials be used which have a low capacity for the absorption of neutrons. This last consideration puts many restrictions in the path of the designer of a nuclear chain reactor.

2. *The Effects of Nuclear Radiation.* The effects of nuclear radiation have several aspects that the designer needs to keep in mind. Perhaps the most important one technically is the fact that the constant bombardment of structural materials and of uranium itself causes changes in their properties. A piece of uranium, a piece of steel or aluminum in a nuclear reactor is bombarded continually by neutrons, by gamma radiation, and to some extent by other nuclear radiations. The result of such bombardment may be a change of shape, an embrittlement, a change in thermal conductivity, or of almost any other property of the material. The rate of corrosion of a material is affected by the presence of nuclear radiation.

Nuclear radiation is dangerous to health. Consequently, the whole reactor structure must be surrounded by a shield which will not be penetrated by the neutrons and other radiation. Radiation is present not only while the reactor is running, but induces a lasting radioactivity in the materials of the reactor. In particular, fuel elements in the reactor become highly radioactive, and when they are unloaded for chemical processing, they have to be handled by remote control. It is unsafe for any personnel to handle them directly. Similarly, maintenance must be held to an absolute minimum, and actual direct access of the operators to the heart of the reactor must be avoided.

3. *Heat Transfer or Removal.* The principal interest in establishing a nuclear reaction is because the fission processes release such enormous amounts of energy, millions of times the amounts of energy released in chemical reactions in corresponding amounts of material. To be sure, the Hanford reactors were not designed for the purpose of producing energy but for the purpose of producing plutonium. Nevertheless, the production of large amounts of energy is associated inescapably with the fission process, and therefore, the designers of the Hanford reactors had to provide some means of removing that energy. It was a simpler problem for them than for the designers of a reactor intended to produce energy. The Hanford designers had merely to get rid of the energy in some way.

The designers of a power reactor must extract the energy in a form which can be put to use. Nevertheless, many of the problems are the same. They differ from ordinary heat transfer problems for reasons that already have been suggested; namely, that the choice of materials is limited by neutron economy, that corrosion effects may be enhanced by the radiation present, and finally that the replacement of parts is difficult or impossible because of the health dangers involved. In a power-producing reactor, the temperature should be as high as possible so that the heat energy removed can be converted into useful power efficiently. This is a real difficulty as we shall see later on and is one point where the designers of the Hanford reactor had a considerable advantage.

4. *Control.* When the first reactors were designed, the question of control was a very critical one. No one knew very certainly whether or not it would be possible to prevent the reactor from running away with itself. We do not want to have a reactor heat up to the point where it will melt and destroy itself. We wish to avoid this for two reasons: first, we do not want to lose the reactor; and second, we do not want to spew radioactive material all over the countryside. By now, we have had enough experience so that we are not very concerned about essential difficulties of control. We are sure that we can build a reactor which we can control. In fact, as I shall mention later, some types of reactor are self-controlling. There does remain, however, a problem of convenience, efficiency, and cost in designing the proper controls to enable them to start, stop,

or maintain at a desired operating level the nuclear chain reaction.

5. *Chemical Processing of Fuel.* Ideally, we would like to put into a nuclear reactor a certain amount of uranium and leave it there until all the uranium had been converted into heat energy and fission products. If that were possible, we would be concerned with chemical processing only in preparing the fuel. Unfortunately, the difficulties both of neutron economy as affected by the growth of fission products and of the corrosion or radiation damage of structural materials or fuel elements make it quite out of the question to consume more than a fraction of a nuclear charge in any known design of reactor. After a certain length of time—and one of the problems in the design of reactors is to make that length of time as great as possible—it is necessary to remove the fuel. It is too valuable to throw away, since it probably still will contain some 90 per cent or more of the fissionable material. Consequently, we have to reprocess it chemically, separating out the fission products, and refabricating the uranium into new fuel elements. This turns out to be one of the most costly processes in the whole business of operating a reactor for power.

I believe it is possible that the nuclear-power industry will stand or fall economically depending on the success which chemists and chemical engineers have in developing cheap processes for purifying and refabricating nuclear fuel.

THE HANFORD REACTORS

I HAVE BEEN SPEAKING of the general technical problems of reactor design. To be more concrete, let me recall briefly in specific terms how these problems are met in the Hanford reactors.

For neutron economy, the reactor is large. It uses graphite as a moderator, and the natural uranium fuel elements are arranged in a lattice. Both graphite and uranium are very highly purified. Cooling channels and protecting coatings of the uranium fuel elements are aluminum of minimum dimensions.

To shield operating personnel, the reactor is surrounded by heavy composite walls and all control and operation are from outside the shields. To reduce corrosion of the aluminum, the cooling water is purified and the temperatures held relatively low. To avoid corrosion or distortion of the uranium, it is canned in aluminum and not left in the reactor very long.

Heat is removed by large volumes of Columbia River water with relatively low exit temperature. The water then is held in retention basins before returning to the river.

Control is by neutron-absorbing rods that move in and out of the reactor. The position of the rods is recorded at the control desk and varied by the operators or automatically in response to instruments.

Chemical processing by a solvent extraction process is done in a separate plant to which the fuel elements are transported in shielded railroad cars, with all operations remotely controlled.

Fundamentally, it is the low exit temperature of the cooling water and the short life of the fuel elements that make this plant impracticable as a power source.

BREEDING

URANIUM 235 is the isotope of uranium in which fission occurs most readily. Unfortunately, it is present in natural uranium only one part to 140. Natural uranium is none too plentiful, and to be able to use only 7/10 per cent of it is frustrating. Neutrons absorbed in the other uranium isotope, uranium 238, lead to the production of plutonium and plutonium is readily fissionable. This fact early suggested the possibility that a reactor simultaneously could produce heat energy from the uranium 235 in natural uranium, and produce plutonium from the uranium 238, and that then the plutonium could be used as fuel for further production of energy. It was even suggested that the plutonium produced might be greater in quantity than the uranium 235 burned up. Such a process is called a breeding process since more fuel can be produced than would be burned.

This is, of course, a very fascinating idea. It turns out, however, that it may not be so very important whether actually more material is produced than is burned. It is obviously possible to produce some plutonium, since that is what the Hanford reactors are for and it should be possible to use that plutonium as fuel for power reactors. Whether the amount of plutonium produced is slightly less or slightly greater than the amount of uranium 235 burned up is not very important. However, we do make a distinction in nomenclature whereby we call a reactor that produces plutonium in smaller quantity than uranium burned a converter and one where the quantity produced is greater than that of uranium burned a breeder. In either case, it should be possible eventually to convert the fission energy of both isotopes of uranium to useful power. In the case of the converter, there would be some loss; in the case of the breeder, the losses in the reactor would be zero, but in either case, there will be losses in chemical processing so that the difference is not very significant. The difference, however, between using just the uranium 235 and eventually using all of the uranium in natural uranium is enormous and well may make the difference between an ample supply of nuclear fuel for many years to come and a rather scanty one.

THE FIRST AEC REACTOR PROGRAM

WHEN the AEC took over the plant and equipment of the Manhattan District in January 1947, the problems that I have been reviewing were already clear. Although the Commission's first responsibility was to prosecute the atomic weapons program with vigor, it soon turned to the possibility of atomic power, both for special military purposes and for ultimate peacetime uses. Early in 1949, Dr. Bacher, my predecessor as the scientific member of the Commission, made a speech in which he outlined the ways in which the Commission was attacking the problems I have reviewed. Essentially, the program consisted of a plan to build four major reactors. Let me describe three of these that have been finished at our Idaho Test Site and why they were built.

The first of them was the so-called materials-testing reactor, *MTR*. It was aimed primarily at getting information on the effects of radiation on uranium fuel elements or

other materials that might be used as tubes for cooling water or as coolants, or containers for uranium fuel elements. The object of this reactor then was to provide very high intensity radiation in a machine so designed that many experimental samples could be placed in it. It now has been running for about 2 years, and it has proved exceedingly useful. Incidentally, it also was a novel kind of reactor and therefore was in itself a step toward the development of new types of reactors.

The second reactor built at Idaho was the so-called experimental breeder reactor, *EBR*. As the name implies, it was specifically aimed at demonstrating whether or not breeding was possible. It has demonstrated that breeding is possible and has had a number of other incidental interesting results.

The third reactor was a special purpose one aimed at providing power for a submarine. You have heard a great deal about that one and about the submarine in which a similar reactor now is being installed.

In all three of these reactors, the neutron economy problem was solved by using uranium from which much of the uranium 238 isotope has been extracted. Whether or not in the long run, this is the kind of reactor we will build for power purposes will be largely a question of economics. Personally, I doubt it, but I do not doubt the wisdom of having built these three reactors and the value of the results we have obtained from them.

A more modest undertaking initiated later is the homogeneous reactors experiment at Oak Ridge. From the atomic point of view, the homogeneous reactor is misnamed. In reality, one can think of it as a lattice where the spacing is very small and the size of the fuel elements is of atomic dimension. To put it more simply, and in terms that will be more familiar to you, the homogeneous reactor is a solution of uranyl sulphate in water. The water serves as the moderator, and the uranyl sulphate molecules serve as the fuel elements in which the chain reaction is set up.

The immediate and obvious advantage of the homogeneous reactor is that fuel fabrication and processing is enormously simplified. The solution is pumped continuously through the reactor chamber and then cooled in outside heat exchangers; some of it can be led off continually for purification and then reintroduced into the circulating stream of combined fuel and moderator. One of the interesting features of the homogeneous reactor is that it turns out to be self-regulating. As the temperature of the reactor rises, its reactivity decreases and therefore it controls itself. One difficulty that was anticipated in the homogeneous reactor was that the water itself would be dissociated by the radiation. This does occur, but it has been found possible to recombine the hydrogen and oxygen formed without too great difficulty.

In addition to the results obtained with the three reactors I have been discussing, and the homogeneous reactor experiment, there has been an extensive program of study of the various associated problems in the laboratory. These range from fundamental studies of what causes radiation damage, or of the absorption probabilities of various materials for neutrons of various energies, to component testing in heat loops, and experimental fabrication of fuel elements. Some of these studies use the various low-power research reactors that have been built.

One of the most interesting experiments was carried out last summer at the Idaho Test Site by Dr. Zinn, director of our Argonne Laboratory, and his associates. We long had worried about what would happen to a water-cooled reactor if the flow of water should be cut off. We were afraid if the water supply was cut off or if the temperature of the reactor rose too rapidly boiling would occur and that this might have disastrous results. Dr. Zinn decided to make a direct approach to this problem and built a small reactor with the deliberate intention of producing boiling. When it was set up at the Idaho testing station, it had an arrangement in it which suddenly ejected the control rods so that the power generated by the chain reaction went up in a fraction of a second from a few watts to many thousands of watts. This had the expected effect on the water. It boiled. It boiled so violently in fact that it was ejected from the reactor in a small geyser. Repeated trials showed that in every case the boiling reduced the power of the reactor so rapidly that no serious damage was done.

This particular experiment illustrates very well the reasons for choosing an isolated area as a site for experimental reactors. It was not only that some of the reactors might be inherently dangerous, but it was felt that an experimental reactor, one built primarily for the purpose of obtaining information, should be operated to extremes, and that it was desirable to have them in an isolated location for that reason. In other words, if you want to get as much information as you can out of a reactor, you need to push it to the point where it might conceivably run into trouble.

RESULTS OF THE PAST 5 YEARS AND PRESENT STATUS OF THE ART

LET ME summarize some of the major results that we have obtained in the last 5 years either directly from the reactors we have built and operated or from laboratory work. I will take them in terms of the five general areas that I enumerated at the start. So far as neutron economy is concerned we have learned a great deal about the probabilities of various nuclear events, including the relationship between the probability of fission and the energy of the neutrons. (This, for example, was tested in the experimental breeder reactor.) We have found that we can use a number of different substances as moderators: beryllium, light water, and heavy water, in addition to graphite.

As to the effects of radiation, the *MTR* has been, of course, of the greatest value as one might expect since it was designed for that purpose. But we also have the benefit of studying the fuel elements that have been in the *EBR* and in the submarine thermal reactor. These, too, have been valuable. We have made a great variety of alloys and have tested various fuel elements. In particular, the submarine thermal reactor has shown that fuel elements sheathed in zirconium will resist corrosion and radiation effects over considerable lengths of time and represent a great improvement over the aluminum-sheathed fuel elements in the Hanford reactors. Radiation effects also have been studied in a variety of coolants including sodium and heavy water.

In the matter of heat transfer we have found we can remove the heat from a reactor by circulating molten sodium-potassium alloy through it. This is the system of heat removal used in the *EBR*. We also have done a great deal of work on pure sodium as a possible coolant and are using it in the second type of submarine reactor now under construction. We have found also that we can use a cooling system of pressurized water. This is the system used in the submarine thermal reactor. We have run reactors at much higher temperatures than we were ever able to run them at Hanford, and therefore, we have moved in the direction of efficient use of the energy from nuclear fission.

As to control and instrumentation, the most striking results have been those already mentioned where we have found that certain types of reactors are in fact self-regulating as a result of boiling or near boiling as the temperature rises. The only other result I will mention is the use of hafnium as a material for control rods. Hafnium is present as an impurity in zirconium and has to be removed before zirconium cladding can be used for fuel elements because it absorbs neutrons. For the same reason it is very useful as a control material.

In the matter of chemical processing, perhaps it is fair to say that most of the work has been accomplished in the laboratory, although we have had experience with actual processing of the various types of fuel elements in the new reactors, none of which is exactly like those at Hanford. We also have proved that the homogeneous reactor will work at least on a small scale, and we, therefore, know that that is one direction in which to hope for improvement.

In the matter of costs, we still have much work to do. None of the reactors that we actually have put up is cheap, either to build or to operate. The submarine thermal reactor probably costs somewhere around $1,500 or $2,000 per kilowatt to build, which is to be compared with the cost of a modern steam plant somewhere around $180 per kilowatt. But the submarine thermal reactor does prove one over-all major result; namely, that it is possible to build a reactor for the production of power that will run for at least reasonably long periods of time continuously and efficiently.

QUESTIONS STILL TO BE ANSWERED

The fundamental question still to be answered is whether a power-producing uranium reactor can be built which will compete with other sources of energy. The answer to that question will be found in the choice of some one of the kinds of reactors we have built already or thought about. None of them has yet been proved to be the ideal or even the best choice. The homogeneous reactor, for example, does simplify chemical processing, but it requires enriched fuel and it is not yet certain that the corrosion problems can be solved. The breeder has not yet been proved on any large scale so that we do not know at all how expensive that may be. The submarine thermal reactor uses such expensive materials for cladding the fuel elements that it is almost certainly not competitive, even though we may be able to produce zirconium at lower and lower costs. It also uses enriched material. And so it goes all through the list.

PROPOSED 5-YEAR PROGRAM

In the last few months we have been reviewing the results that we have obtained up to the present time and planning what would be best to do over the next few years in order to arrive at an economical solution of the problem of nuclear power. We have decided that there are six programs that we should pursue. One of these is the general program that we obviously must continue, the program of research on fundamental properties of materials, on nuclear reactions, on components that might go into the reactors of the future, and on chemical processes. This work will be continued principally in our Argonne and Oak Ridge laboratories. In addition to this general research and development work, we wish to build five reactors of varying size and cost. The Commission recently submitted to the Joint Committee on Atomic Energy a special report on the reactor program prepared at the request of the committee.

The first of these reactors in our new program has already been publicly announced. It is the so-called *PWR* reactor which is designed to generate at least 60,000 kw of electric power. It will use slightly enriched uranium as fuel, ordinary water as a moderator and coolant. The reactor will be operated under reasonably high pressure and temperature, not nearly so high as are used in modern steam plants, but as high as we feel safe in terms of our present knowledge. Specifically, the water in the reactor will be under 2,000 pounds per square inch pressure and at a temperature between 500 and 600 F. Steam will be delivered to the turbine at about 600 pounds per square inch. The temperature is limited by the corrosion of the fuel elements and piping and container, and the pressure is limited by the strength and size of the vessel in which the reactor must be contained. One of the difficult problems in this reactor will be that of getting control mechanisms to operate in a high-pressure vessel. Principally, we hope to learn from this reactor how such a plant may stand up under ordinary operating conditions of central station electric power plant and how much it costs to build and operate it. We have no expectation that this reactor will produce power as cheaply as a modern coal-burning plant, but we hope to learn how costs can be cut in later plants.

The second new reactor which we wish to build is a breeder of intermediate size. It will not be of direct interest from the point of view of economic power, but it will be much larger and much more nearly a power-producing, continuously operating reactor than the small experiment we have been running in Idaho. The scale-up planned is from 1,400 to 62,500 kw of heat, and from 170 to 15,000 kw of electric power. Temperatures and steam pressure will be increased to values appropriate to a full-scale power breeder reactor. Auxiliaries such as pumps, heat exchangers, valves, etc., will be of sizes suitable to a full-scale reactor.

Our third step is based on the boiling experiment that I already have described. It will be an attempt on an intermediate scale actually to use boiling of the water as a method of heat extraction. We hope in this way to get a very cheap method of getting the heat out of the reactor and possibly of eliminating one step between the coolant in

the reactor and the turbines which turn the generator. It is planned to feed the steam generated in the reactor directly to the turbines. Present plans call for 20,000 kw of heat and 5,000 kw of electric power.

The fourth reactor which we intend to build is a larger version of the homogeneous reactor. Again, it will be a step in the direction of a practical power-producing unit and should give us information about corrosion, chemical processing, and operating conditions that cannot be obtained with the small machine now in use at Oak Ridge. Present specifications call for only 3,000 kw of heat in this reactor experiment compared to 1,000 in the present experiment. The next step, already planned, calls for 65,000 kw of heat in a homogeneous reactor which will breed uranium 233 in a blanket of thorium surrounding the chain reacting core.

The fifth reactor experiment which we plan to build is a little different from any that I have described. I have mentioned that the breeder reactor uses sodium-potassium alloy as a coolant. The Hanford reactors use graphite as a moderator. We hope to be able to combine these two materials, getting the advantage of high temperature without high pressure from the sodium coolant. To test this combination, we will build a reactor generating about 20,000 kw of heat but without any electric generating plant attached.

In addition to these new proposals, we shall continue several other programs already under way. These include the so-called intermediate submarine reactor now under construction at West Milton, N. Y., near Schenectady, and the development of a reactor to propel aircraft. Though the aims of both of these projects are special, they undoubtedly will contribute to the general technology.

COSTS

It is evident that we can build power plants which will convert the energy released in nuclear fission into electric energy to be fed into transmission lines. The question that has not been answered and may not be conclusively answered even by the program I have outlined is whether this power can be produced cheaply enough to be of general use. The AEC believes that it can be done and this is the opinion also of the several private industrial groups who have been studying the problem for several years at the invitation of the Commission. At present, the power delivered by the submarine reactor at our Idaho plant costs about ten times as much as it would if we bought it from the Idaho Power Company. From this figure you can see that it will require all the ingenuity of our staff, our contractors, and private industry working together to get costs down, but it is reasonable to assume that eventually this will be done.

INDUSTRIAL PARTICIPATION

These private industrial groups I have mentioned are interested in more than just cost studies. They have assigned able members of their staffs to design studies of nuclear power plants and in some cases are doing considerable amounts of research at their own expense. It is a mistake, however, to think that private industry can or will pick up the burden of development of nuclear power plants in the present state of the art. It is a field in which knowledge and competence are still largely confined to Government laboratories and in which the financial risks are still too great for private industry to carry alone.

The Commission hopes for greater and greater participation by industry both technically and financially and for a gradual transfer of the nuclear power part of the Commission's responsibilities to private enterprise. To discuss the many problems of such a transfer would need another speech. Personally, I feel they are just about as difficult as the technical problems of getting cheap nuclear power. Time, money, and thought will be needed for both set of problems. I believe they can be solved.

CONCLUSION

To establish a nuclear-power industry in this country will be a great achievement. If power becomes cheaper and more plentiful, our material standard of living will be raised. In other countries the effect may be even greater. By the accident of history the first use of this great new discovery has been in the development of weapons of war, weapons of appalling magnitude. The nations of the world have today the means to destroy each other. They also have, in this same nuclear energy, a new resource which could be used to lift the heavy burdens of hunger and poverty that keep masses of men in bondage to ignorance and fear. Toward this peaceful development of nuclear power we have, all of us, a high obligation to work with all the ingenuity and purpose we possess.

Rotor Lowered Into Stator Core

This 75-ton rotor of a 17,895-kva hydraulic turbine generator being built by the Elliott Company, Ridgway, Pa., is lowered gently into position in the core of its stator. The rotor is 18 feet in diameter and must be placed level and square with a 1/2-inch air gap.

Skin-Effect Bars of Squirrel-Cage Rotors

MICHAEL LIWSCHITZ-GARIK
FELLOW AIEE

IN ORDER TO INCREASE the starting torque, larger induction motors are built usually with skin-effect bars in their rotor. Fig. 1 shows various types of skin-effect bars. Types *A*, *B*, and *C*, mostly type *C*, are used in induction motors; type *D* is used in synchronous motors. The analytical investigation of the increase of resistance and decrease of slot-leakage reactance of the skin-effect bars is possible under the following assumptions: (1) the vertical component of the slot flux is negligible; (2) the permeability of the iron is infinite; (3) the resistivity of the conductor is constant over the depth of the slot; and (4) the current density along any line parallel to the bottom of the slot is constant.

The analytical solution leads to Bessel, Hankel, and hyperbolic functions for the bar type *A*, to Bessel and Hankel functions for the bar type *B*, and to hyperbolic functions for bars type *C* and *D*. The evaluation of the somewhat complicated equation for the bar type *A* can be facilitated by means of curves representing the expression containing the Bessel and Hankel functions as a function of the dimensions of the bar and the frequency. For the mostly used bars type *B* and *C*, the ratio of a-c to d-c resistance and the ratio of a-c to d-c slot-leakage inductance can be expressed as functions of a simple quantity

$$\xi = 0.316\, h\sqrt{\frac{a}{b}\frac{f}{\rho}}$$

where h is the height of the bar in inches, a the width of the bar, b the width of the slot, f the frequency of the rotor current, and ρ the resistivity of the rotor material in micro-ohms per cubic inch ($\rho = 0.825$ for copper at 75 C). Figs. 2 and 3 show the ratios r_{ac}/r_{dc} and l_{ac}/l_{dc} as functions of ξ. $\beta = 1$ represents the straight bar type *C*. It can be seen from these figures that the tapering, at a given value of ξ, influences the inductance much less than the resistance. The tapering results in a considerable increase of the starting torque.

A comparison of the various bar types for a specific case (Fig. 4), where the area of the bar is equal to 0.58 square inch, the height of the bar is equal to 1.4 inches, and the frequency is equal to 60 cycles per second, is shown in the following tabulation:

	r_{ac}/r_{dc}	l_{ac}/l_{dc}
Type 1	7.2	0.49
2	4.7	0.38
3	5.3	0.44
4	3.6	0.40

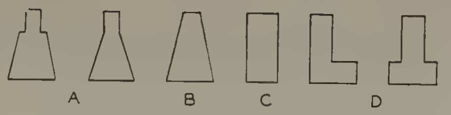

Fig. 1. Various types of skin-effect bars

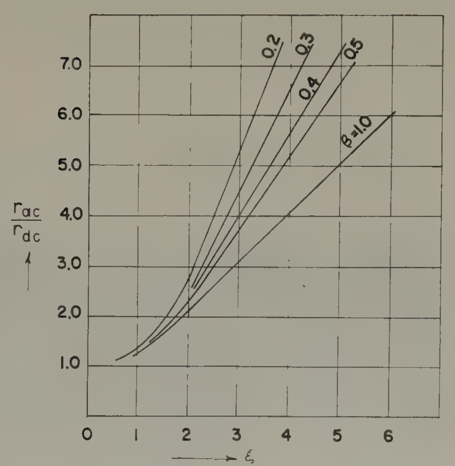

Fig. 2. Ratio r_{ac}/r_{dc}, for the tapered bar and straight bar

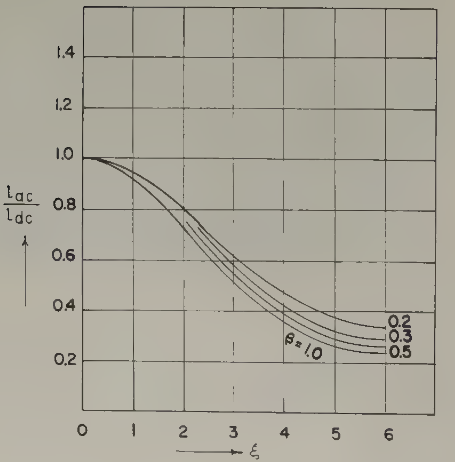

Fig. 3. Ratio l_{ac}/l_{dc}, for the tapered bar and straight bar

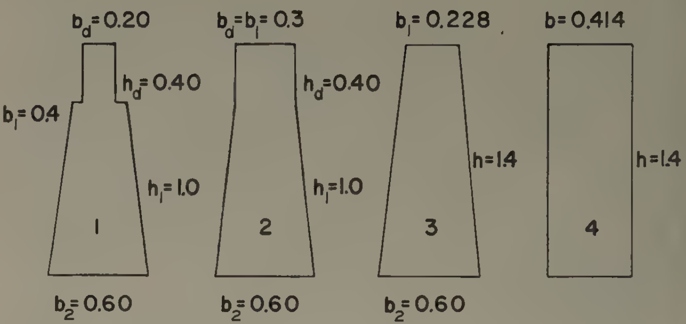

Fig. 4. Comparison of r_{ac}/r_{dc}, and l_{ac}/l_{dc}, for various types of skin-effect; bars with the same area

Digest of paper 54-15, "Skin-Effect Bars of Squirrel-Cage Rotors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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Control of Thermal Environment of Buried Cable

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THE OPERATING TEMPERATURE of underground current-carrying conductors is affected directly by the thermal resistance and capacitance of their immediate environment. With pipe-type or directly buried cable, where soil alone comprises that environment, the thermal characteristics of that soil are of major importance. Soils vary considerably in respect to these characteristics, even in a given locality, and along the route of a cable line several miles in length, the range in values usually will be appreciable.

Economic utilization of such a line is restricted if its available capacity is limited by the presence of extremely unfavorable thermal conditions along a small portion of its length. It is desirable, therefore, to take corrective action wherever there exist restrictive conditions of exceptional severity.

A limited investigation has been conducted to determine the most practical solution to this problem. The necessary corrective action could take the form of improving the thermal characteristics of the soil immediately surrounding the cable or of replacing that unsatisfactory soil by backfill of superior characteristics in the amount necessary to effect the desired improvement. Investigation showed that the former approach is not practical, and that the latter is generally the most satisfactory despite the costs involved in the extensive excavation and backfilling which it entails.

The characteristics of an ideal backfill can be postulated. Primarily, it should be composed of a low-cost material with a high intrinsic thermal conductivity, have a high solids content, and be characterized by retention of moisture under adverse conditions. The material which most nearly meets these conditions is quartz, but because properly graded pure quartz sand is unavailable at low cost in the Philadelphia (Pa.) area, the backfill adopted for field use as a result of this investigation was a silicic sand, designated concrete sand, locally available in quantity at low cost. Its thermal conductivity was found to be satisfactory not only at normal values of moisture content, but also at a value (0.7 per cent by volume) lower than any ever likely to be encountered in the field. Its water retention characteristics were evaluated and found satisfactory. Its specification limits of grain size distribution are such as to assure a uniformly high solids content. This high solids content is an important factor in producing the foregoing attributes, and inspection of the grain size distribution provides a ready means for control of this characteristic.

Several sands and a sandy loam were subjected to a temperature of 180 F over a period of from 20 to 70 hours. A comparison of the samples showed that their final moisture contents, while apparently independent of their initial moisture, varied directly as their solids contents.

Even with the most economical backfill material, it is desirable to minimize the amount of excavation and backfilling to be done. The work of investigators such as J. H. Neher[1] has provided a means for determining the minimum amount of such work necessary to achieve a given degree of improvement. The principle of superposition is utilized, in that the heat flow from a cable system is treated independently of other thermal gradients. On

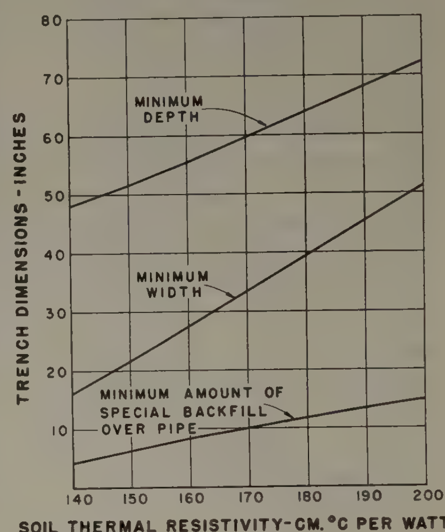

Fig. 1. Trenching for corrective backfilling; size of trench to receive backfill having a thermal resistivity of 70 cm C/watt, in order to reduce the over-all effective thermal resistivity to 120 cm C/watt in areas where the soil has the resistivity shown on the abscissa. These dimensions assume a 6-inch pipe with 36 inches of cover

this basis, it is possible to determine, for a given installation, the minimum trench dimensions which fulfill the following simple condition: If the soil from the trench is replaced by a backfill having a given thermal conductivity superior to that of the original soil, the thermal resistance of the backfill within the trench, in series with that of the surrounding soil, is equal to the total thermal resistance which would be encountered if the pipe were buried in a homogeneous soil having the maximum acceptable thermal resistivity. Given a backfill having a resistivity of 70 cm C/watt, Fig. 1 gives the minimum trench dimensions necessary to achieve an over-all effective resistivity of 120 cm C/watt in soils with resistivities varying from 140 to 200 cm C/watt. The 6-inch pipe and 36 inches of cover on which Fig. 1 is based have been used in Philadelphia Electric Company 69-kv pipe-type installations. Similar curves can be constructed, of course, for other pipe sizes and depths of burial.

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III. BENJAMIN FRANKLIN

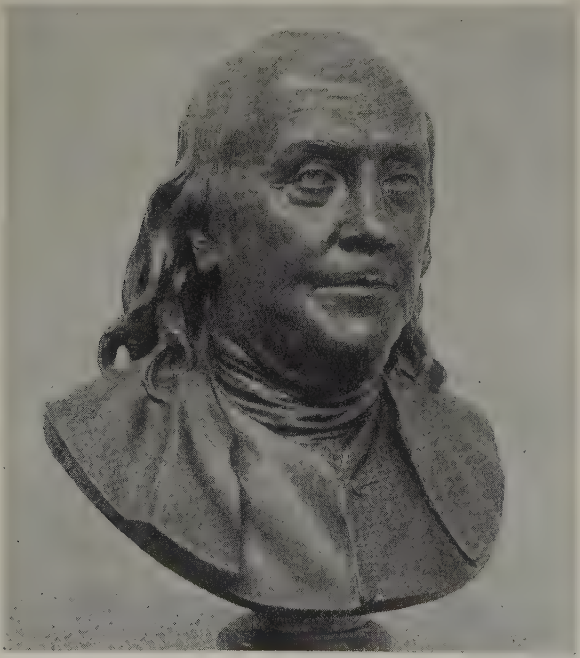
and the universal nature of electricity

BERN DIBNER
FELLOW AIEE

Benjamin Franklin established the identity of friction-produced electricity and lightning, proposed the principles of the lightning rod, and evolved the single-fluid theory of electricity. He concluded that the peculiar property of charged bodies to attract and repel one another was the transfer of electric fluid, thus providing a complete understanding of the operation of capacitors and charged bodies.

THERE WAS A SPAN of a century between the activity of Guericke and Benjamin Franklin. In this time several major contributions to the ever-growing interest in electricity were made, in particular the independent invention of the Leyden jar, or first capacitor, by E. G. von Kleist of Pomerania and Petrus van Musschenbroek of Leyden. Before Franklin, materials used in electrical experiments were separated into "electrics" and "nonelectrics." The former were those bodies that could be charged by friction while held in the hands of the experimenter, while "nonelectrics" included those that could not be so charged.

Franklin's interest in electrical phenomena was aroused when he attended a lecture presented by Dr. Spencer of London, in Boston sometime between 1744 and 1746. Franklin was then a man of 40, soon to retire from a successful career as a printer. He immediately purchased all of the lecturer's electric equipment and began to experiment. The generator of Franklin's day was a glass sphere or cylinder rotated by a crank, and against which a leather, felt, or cloth cushion, sometimes impregnated with a mercury amalgam, would be pressed. An electric charge so generated would be drawn to a metal bar or chain suspended by silk strands and transferred to the metal rod projecting through the cover of a Leyden jar. Such a charge was used to demonstrate before Louis XIV how 180 soldiers of his guard or how 700 monks of a convent in Paris, joined hand in hand, would jump simultaneously when a jar's charge was transmitted through them. From his experiments Franklin concluded that the peculiar property of charged bodies to attract and repel one another was not a manifestation of two different kinds of electricity as believed by the electricians before him, but the transfer of electric fluid from one body to another. With this conclusion Franklin provided a complete understanding of the operation of all forms of capacitors and charged bodies. He analyzed the charge in a Leyden jar and found that it always was charged positive on one metallic coat and negative on the other (the very terms "positive," "negative," "plus," and "minus" were his permanent contributions to our electrical vocabulary) and explained the principles of electrostatic induction. He claimed that although opposite in sign, the charges were of equal magnitude and proceeded to demonstrate this by suspending a pith ball equidistant between two wires connected, one each, to the two surfaces of a Leyden jar. The ball oscillated from wire to wire until the charges had equalized and the pith ball hung limp between them. He devised the "Franklin Pane" which consisted simply of a thin sheet of glass on either side of which were fixed thin metal sheets (a parallel plate capacitor), and showed that it was the glass that held the charge. He also discovered that charges reside on the outside of a charged hollow conductor, that when one body contains more than its normal quantity of the electric fluid, a wire connecting it to a neutral or negatively charged body permits the charge to become uniformly distributed between them. If not



Modeled from life by Houdon. Courtesy Burndy Library

Benjamin Franklin

Bern Dibner is president, Burndy Engineering Company, Inc., Norwalk, Conn.

connected, but placed sufficiently close together, the charge passes between such bodies in the form of a spark.

To Peter Collinson of the Royal Society he communicated his observations and theories about lightning, which were basically that electric charges were raised from the sea and from the land by evaporation. These gathered in clouds of differing charges which, as they approached one another, discharged with a display of thunder and lightning. Therefore, contended Franklin, the action of an electric machine and lightning were similar. He enumerated the similarities thus: (1) the resulting light and sound are similar, and both phenomena are practically instantaneous; (2) the spark, like lightning, is able to set bodies on fire; (3) both can kill live creatures (Franklin killed a hen by the discharge of several Leyden jars); (4) both do mechanical damage and have a smell like burnt sulphur (this led to the discovery of ozone); (5) lightning and electricity follow the same conductors and both pass most readily to sharp points; (6) both are able to destroy magnetism, or even to reverse the polarity of a magnet; (7) both are able to melt metals.

From an old engraving

Franklin and Electricity
1752

Finally, as a result of both theoretical analysis and observations of experiments, Franklin concluded that a sharp pointed object, especially if grounded, was more prone to draw off an electric charge than was a dull, rounded one. Coupling this conclusion with his understanding of the nature of lightning, Franklin conceived the notion of drawing off a lightning charge by means of a tall rod, the top of which terminated in a point and the bottom set in the ground. This became the lightning rod which served not only as a great benefaction in eliminating the hazard of destructive lightning strokes, but it also helped popularize Franklin's name on both sides of the Atlantic. The King of France sent a special letter to the Royal Society complimenting Mr. Franklin on his valuable contribution.

To confirm the electrical nature of lightning experimentally, Franklin made his famous kite experiment in June 1752. This he described in a letter to Collinson dated October 1, 1752. A kite of cedar ribs was covered with a thin silk handkerchief to which a sharp pointed wire was added at the top and the usual tail at its bottom. Franklin then added a silk ribbon to the bottom of the twine and at this juncture fastened a key. In flying the kite in a storm, the experimenter stood in the shelter of a door so as not to wet the silk ribbon. He noted that when the thunderclouds cross over the kite "the pointed wire will draw the electric fire from them, and the kite, with all the twine, will be electrified and the loose filaments of the twine will stand out every way and be attracted by the approaching finger." He noted: "At this key the phial [Leyden jar] may be charged, and from electric fire thus obtained, spirits may be kindled, and all the other electrical experiments be performed." He later discovered that thunderclouds may be charged either positively or negatively. De Romas, a French experimenter, repeated Franklin's experiments and succeeded in drawing a spark 8 inches long from the clouds. Dalibard (who translated Franklin's book into French) set up a pointed rod at Marly, near Paris, following Franklin's instructions. Here his deputy drew sparks during a thunderstorm in May 1752. The idea spread to England and other nations on the Continent. In 1753, a Professor Richmann of St. Petersburg was killed by a charge that was brought down an improperly terminated rod; this unfortunate result thus made him the first martyr to the new electrical science. The lightning rod idea expanded in Franklin's mind so that he asked "May not the knowledge of this power of points be of use to mankind, in preserving houses, churches, ships, etc., from the stroke of lightning, by directing us to fix on the highest part of these edifices, upright rods of iron made sharp as a needle, and gilt to prevent rusting, and from the foot of these rods a wire down the outside of the building into the ground, or down round one of the shrouds of a ship, and down her side till it reaches the water?"

With the publication of his book "Experiment and Observations on Electricity, made at Philadelphia in America" in London, 1751, his reputation grew rapidly in Europe. This book was reprinted five times in English in his lifetime and in several editions in French, Italian, and German. On his visits to England and France he became one of the most popular men of his time. He received a doctorate from Oxford, was elected Fellow and Manager of the Royal Society of London, and was chosen one of the eight foreign members of the Royal Academy of Sciences of France, the only American to be so elected for the next hundred years.

The enthusiasm which Franklin displayed in his electrical research is well demonstrated in his third letter to Collinson. In it Franklin sums up by describing an event to celebrate that fruitful year, 1747, "in a party of pleasure on the banks of the Skuylkil a turkey is to be killed...for dinner by the electrical shock, and roasted by the electrical jack before a fire kindled by the electrified bottle: when the healths of all the famous electricians in England, Holland, France and Germany are to be drank in electrified bumpers, under the discharge of guns from the electrical battery."

Ventilation of Inner-Cooled Generators

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MEMBER AIEE

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Inner-cooling of rotor and stator windings makes possible a substantial increase in the ratings of turbine generators. Improvements in associated components such as ventilation arrangements, blowers, coolers, and seals permit a compact and efficient construction.

THE electric power industry has been expanding at such a high rate during recent years that the generating capacity is being doubled approximately every decade. In parallel with the growth of the power systems, there has been a corresponding increase in demand for high-speed generating units of larger ratings.

Such units result in more economical operation and, consequently, are particularly attractive to the user. This trend is reflected in the curve of Fig. 1 which outlines the rapid rise in the size of 3,600-rpm units manufactured for the power industry. The slope of the curve indicated a number of years ago that very large units eventually would be required.

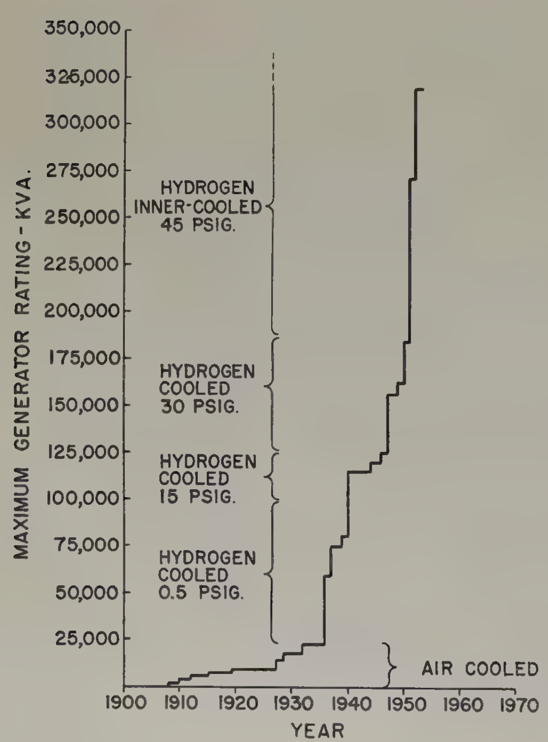
Further increases in generator size, however, were limited principally by mechanical requirements. Rotors were rapidly approaching the point where the strength and size of the forgings available within the foreseeable future would prevent any additional increase in diameter. Further restrictions were imposed by the permissible shipping dimensions which determine the maximum size of frame housings that may be constructed as integral units.

To build higher capacity generators, therefore, it was necessary to increase the specific rating of the machine and to make a more effective use of the available materials. Limitations in specific rating were recognized to be determined primarily by the maximum allowable operating temperature of the electrical insulation and by the ability to dissipate the heat loss generated within the stator and rotor windings.[1,2]

In conventional units, all the coil losses must be dissipated through the electrical insulation so that inherently an appreciable thermal gradient occurs at this point. With any of the cooling methods that are confined to the thermal circuit external to the insulated coil, the coolant exercises only a secondary role in reducing the temperature rise of the electric conductor.

To remove the limitation, it was necessary to develop a more effective cooling means by which the thermal barrier of the electrical insulation could be eliminated. This objective could be realized by circulating the coolant in direct, or nearly direct contact with the conductors. The plausibility of such a scheme has been demonstrated by laboratory investigations on full-size coil models, as previously reported.[2] Increased attention has been paid to this subject by other investigators who concur in general that an appreciable increase in specific rating can be obtained.[3–8]

The authors' company recently shipped its first completely inner-cooled turbine generator. In this unit both the rotor and stator coils are directly cooled to satisfy the base requirement of 80,000 kw



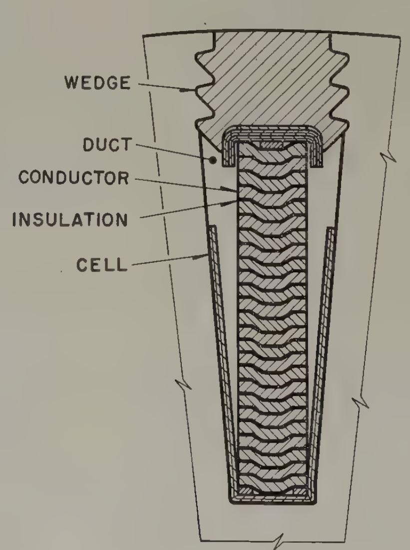


Fig. 1 (left). Maximum available kva rating of individual 3,600-rpm turbine generator. Fig. 2 (above). Side-ventilated rotor coil

Condensed text of paper 54-50, "Ventilation of Inner-Cooled Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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The authors wish to express their appreciation to C. M. Laffoon and L. A. Kilgore for their encouragement in the development of the inner-cooled generator construction.

at 30 pounds per square inch gauge (psig) with a capacity rating of 100,000 kw at 45 psig. The results of a rigorous series of shop tests,* demonstrated that such machines will operate satisfactorily at these high unit ratings.

Inner-cooling of turbine-generator rotor and stator coils is accepted now as offering the possibilities of a sufficient increase in specific ratings to permit the manufacture of generators having greater capacities than heretofore available. It again becomes necessary to review the functions of associated components, such as ventilation schemes, blowers, coolers, and gas controls. To this end considerable effort has been expended to refine concepts and to develop the optimum design of each component.

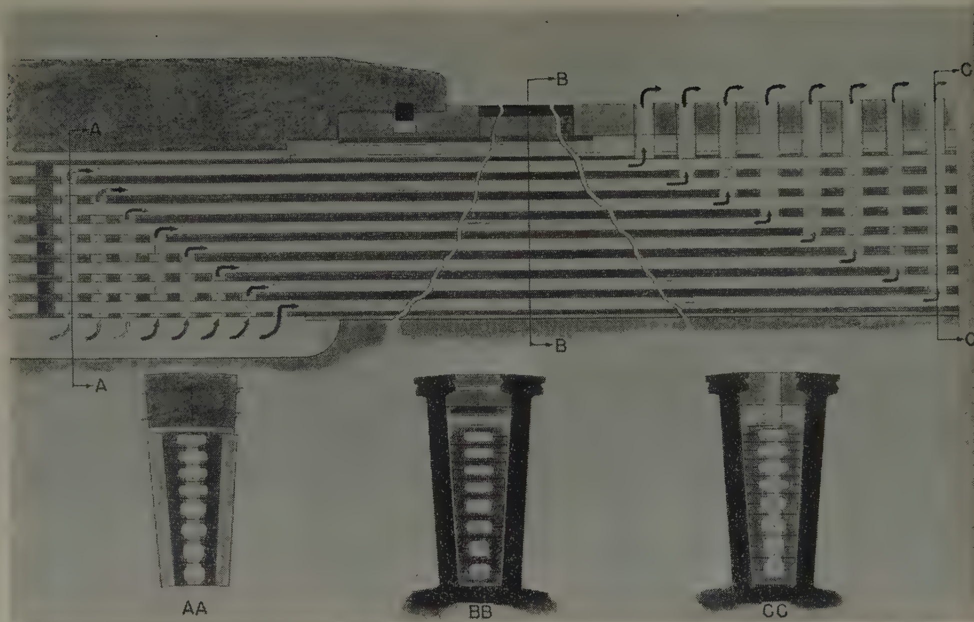


Fig. 3. Ventilation pattern and construction details for inner-cooled rotor coil

ROTOR VENTILATION

Many schemes have been proposed in the past for removing the heat directly from the conductors.[9] In some, the cooling gas would flow radially outwards between the two halves of a coil while in others the gas would flow along the sides of the coil.

A modification of the side-ventilated coil was used some 14 years ago by the company with which the authors are associated. It was applied to the rotor windings on a 25,000-kva 3,600-rpm synchronous condenser which was placed in operation during 1939, and on a 28,570-kva 3,600-rpm turbine generator which was installed in 1944. Both units have been in continuous operation under normal schedules and system conditions since installation and no rotor winding difficulties have been experienced.

In these machines the rotor slots were shaped so that axially located ventilating ducts were provided between the sides of the rotor coils and those of the slots, see Fig. 2. The hydrogen gas was brought in at each end of the rotor and passed along the sides of the bare conductors to the mid-section of the rotor where it then was discharged through radially located ducts into the annular gap between the rotor and the stator.

These units were designed for operation at 0.5 psig hydrogen pressure at normal rating and were to be suitable for operation at higher gas pressures for higher capability ratings. The increase in rotor ampere-turn output was of the expected order of magnitude for this particular type of construction. All of the additional rotor capacity at high gas densities, however, could not be fully utilized, since the machine proportions and characteristics were fixed for the 0.5 psig hydrogen condition.

Further development lay dormant during the war years, but was revived again shortly thereafter. At that time the problems were reviewed and it was concluded that additional benefits could be derived from a modification of the methods previously considered.

The embodiment finally employed in the inner-cooled rotors provides for the flow of coolant through ducts formed directly from the conductors.[2] The straps are constructed in a channel shape, Fig. 3, placed together to form rectangular ducts. Two conductors form a parallel turn so that no insulation is required between the channel legs. The insulation between successive turns is confined by the channel backs where it is removed from the ventilation passages.

Coolant is introduced to the rotor through the annular space between the retaining ring end plate and the shaft. The gas then flows axially along the conductor towards the rotor center line where it then is discharged into the air gap through another series of orifices. The physical details of Fig. 3 illustrate the electrical insulation schemes employed to insure proper ground protection. In the main body of the rotor the insulation is the same as in the conventional unit while at the discharge section the insulation and creepage paths duplicate the construction utilized for years under the retaining rings.

In order to reduce the length of any one path being served by the coolant, thus further increasing the rotor performance, the end turns are separately ventilated.

The external arrangement of the discharge orifices in the wedge section may be seen in Fig. 4, while the construction of baffles, end coils, and ports may be observed in Fig. 5.

By introducing the coolant in the manners described, the centrifugal forces generated by the rotor are employed to generate part of the differential pressure producing flow in the coils. With this arrangement, it also is possible to

* Test Results on an Inner-Cooled Generator, **W. C. Brenner, P. R. Heller.** This article, which is based on a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, will appear in a subsequent issue of *Electrical Engineering*.

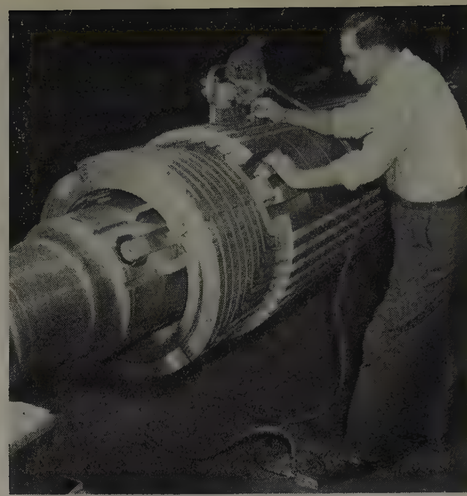


Fig. 4 (left). Discharge ports at center of inner-cooled rotor. Fig. 5 (right). End view of inner-cooled rotor and winding

utilize the blower pressure to augment the rotor action so as to obtain additional flow and cooling.

STATOR COIL VENTILATION

THE inner-cooled stator coil consists of the conventional stacks of insulated conductor strands separated by a group of rectangular metal ducts. These thin walled ducts are drawn from high-resistance nonmagnetic material to minimize the eddy losses. Since these tubes are closely coupled by capacitance to the conductors, they operate at the same potential and need only be insulated in the same manner as the individual conductor strands. Depending on the width of the slot employed, a double or a single Roebel is used to keep the eddy current losses to a reasonable value.

The thermal gradients existing with this construction are illustrated in Fig. 6 in relation to the operating gas pressures. Since only a relatively thin insulation is employed between the strands and the ducts a small thermal drop is experienced at this point as compared to the drop through the conventional thick ground wall which may be as large as 80 per cent of the total copper rise. The major portion of the temperature rise for the inner-cooled coil is directly dependent upon the gas temperature rise and the surface rise. By increasing the mass flow of the coolant, such as by raising the absolute pressure of the gas or increasing the differential blower pressure, the temperature gradients may be reduced to a very low value.

The coolant is introduced at the collector end of the coil, Fig. 7, and flows completely through the coil length to the turbine end discharge. A typical coil end section showing the coil connections and ducts is contained in Fig. 8. A silicone rubber cap is placed over the coil end assembly, Fig. 9, which also serves to help direct the gas to the coil ducts. Insulation to ground and between the coils is provided by conventional solid insulation, while the coil ends are isolated from ground through suitable creepage and striking distances as previously described.[10]

As illustrated in Fig. 9, no auxiliary duct connections are required between the vibrating core and frame so that a coil end transposition may be incorporated as in conventional units to reduce the losses in these parts. Fig. 9 also shows the arrangement of the bracket with gland seal, bearing, and blower end bell.

In the foregoing discussion the coolant has been described as a gas which in most applications would be hydrogen at some intermediate pressure. The authors have pointed out previously[2] that other coolants, such as oil or water, also would be effective providing they could be employed without any sacrifice in operating reliability. Actually an equivalent cooling can be obtained with hydrogen[2] so that at the present development of the art, it appears desirable to retain the simpler all-gas system as long as it is possible to obtain easily the ratings required by industry. The general useful range of coil ratings for rotor and stator coils is indicated in Fig. 10 relative to the performance of conventional coils. Consequently, at the present time the limitation in upper rating is sufficiently removed that it will be possible to extend the basic principle to the largest capacity generators required.

STATOR TEMPERATURE DETECTORS

IT has been past practice to obtain some measure of the stator coil temperature by means of temperature detectors located between the two coils occupying a given slot. Because of the nonhomogeneous thermal properties of insulation and the heat flow patterns existing with this type of construction, the resultant indicated temperatures have been recognized as being only a fraction of the actual copper temperature. Through experience, tests, and calculations, the allowable rise for the operating conditions utilized to date has been established such that the maximum conductor temperature should not exceed the allowable value of 130 C as proposed by the AIEE Standard.

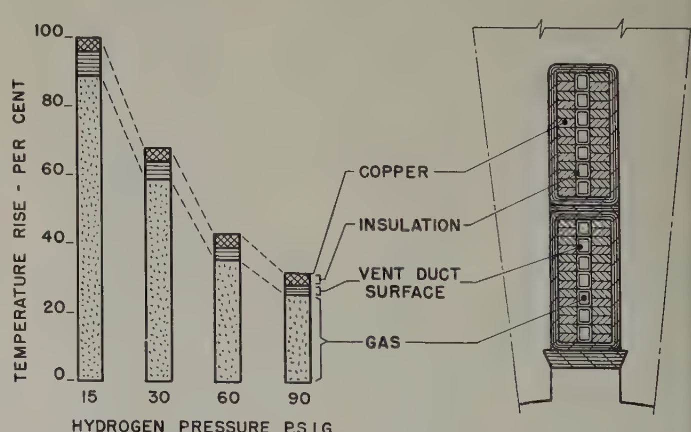


Fig. 6. Temperature rise through inner-cooled stator coil elements relative to maximum copper temperature at 15-psig hydrogen pressure

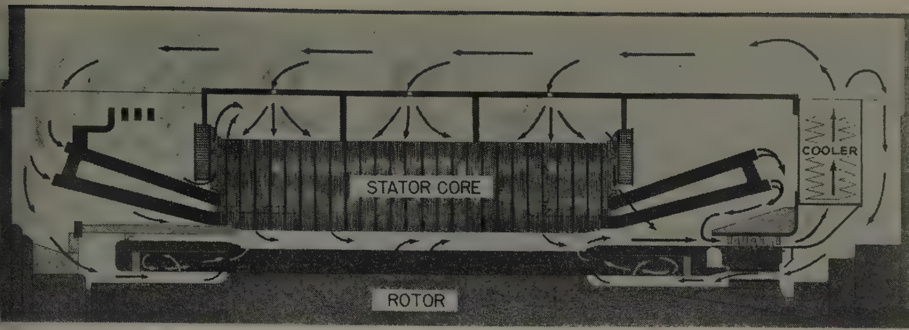


Fig. 7 (above). Schematic cross section of inner-cooled generator illustrating ventilation components. Fig. 8 (right). End construction of stator coil winding

With the inner-cooled construction the maximum copper temperature occurs outside of the core section at the extreme discharge end of the coil. The temperature of the coil within the core section is considerably reduced and would have an average value appreciably less than the maximum temperature at the discharge point. Since a negligible amount of the coil loss is dissipated to the core section, less cooling of the core is required and a higher core temperature may be employed. Consequently, the combination of lower copper temperature and higher core temperature results in less differential expansion thus providing more desirable operating conditions.

The temperature of the gas leaving the coil is more representative of the actual copper temperature, being lower by only the small amount of insulation and surface drop. Temperature detectors then may be located in the exhaust gas stream to provide a more accurate means of measurement.

VENTILATION ARRANGEMENT

It has been demonstrated that inner-cooling derives its effectiveness directly from the intimate association of the coolant with the current-carrying members thus eliminating the thermal barrier of the insulation. Increasing the mass flow by raising the gas pressure further has increased the heat-dissipating characteristics.

Units employing these features, therefore, require less gas flow than conventional machines, thus permitting a correspondingly higher gas rise for the same operating copper temperature. The resulting proportions of the machine elements make it possible to provide a more compact and effective ventilation arrangement.

With increased specific rating, such machines inherently require larger air gaps to maintain the same short-circuit ratios. Consequently, in conjunction with the reduced gas volume flow the air gap may be employed as a duct for collecting the rotor and core cooling gas as shown in Fig. 7.

From the air gap the gas passes directly to the blower which forces the hot gases through the cooler and back to the rotor and stator coils. A barrier in the air gap at the end opposite to the blower prevents by-passing of the gas and produces a pressurized zone for feeding the various rotor and stator coils. A simple ventilation arrangement thus is obtained as shown.

By removing the blower from one end of the machine and combining it with the blower on the cooler end, it is possible to obtain a high-pressure blower in the same total over-all length of the two original low-pressure blowers. With

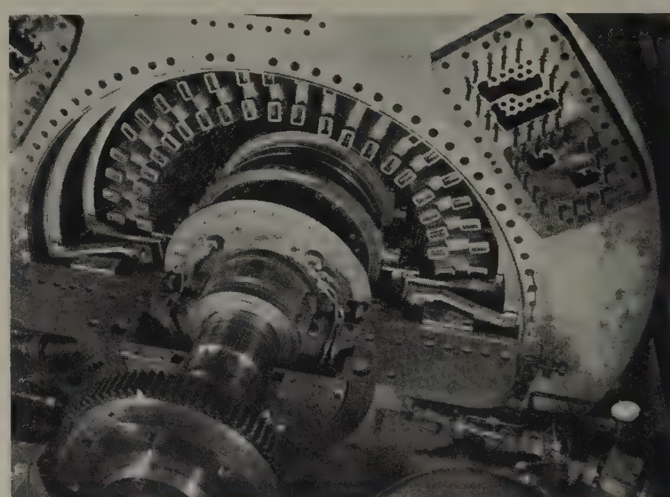
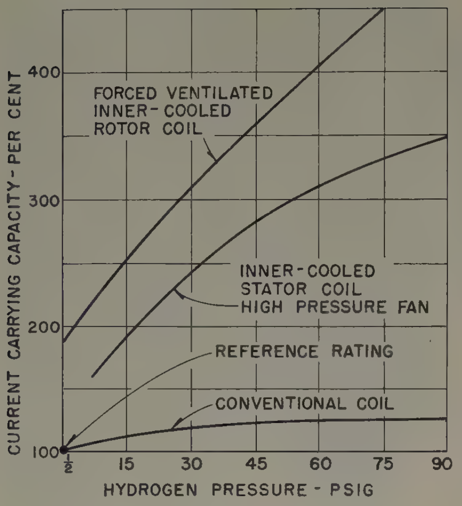


Fig. 9. End view of inner-cooled stator windings and bearing bracket

the reduced air flow, and higher gas pressures and densities, the cooler size may be reduced to a smaller volume than previously used, thus obtaining a compact cooler arrangement.

The cool gas from the cooler then may be circulated to the required locations through suitable ducts between the stator core and the frame wall. Since these ducts are relatively small, this arrangement permits the construction of larger ratings without increasing the frame size beyond shipping limitations. The frame also is maintained uniformly at the cool gas temperature thus eliminating the temperature gradients along the structure.

With the system described, the temperature rise produced by the blower is removed by the cooler before the gas enters the rotor and stator coils, thus providing the minimum operating temperature. This is particularly advantageous in permitting operation with air for servicing and balancing.



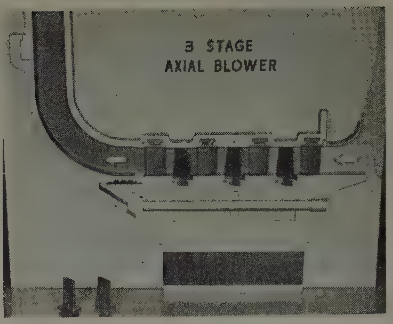


Fig. 10 (left). Current-carrying capacity of rotor and stator coils as a function of hydrogen pressure. Fig. 11 (above). 3-stage axial blower

struction of such a blower may be seen in Fig. 12. These blowers are an integral part of the unit so that no dependence is placed on auxiliary equipment.

Since less cooling gas is required, it is possible to develop the higher differential pressures without exceeding the blower losses of conventional machines. The stage efficiencies are high and since only the entrance and exit losses of one blower are involved, the over-all efficiency is maintained. The results are indicated in Fig. 13 which compares the performance of an inner-cooled unit versus that of a conventional unit for the same maximum capability. The standard unit develops its maximum capability at 30 psig in this case while the inner-cooled machine operates at 45 psig. It will be noted that both the rotor loss and blower loss are less for the inner-cooled unit even at the higher gas pressure because of the reduced physical size. Variations will be experienced because of design modifications to suit individual cases, but in general the total windage losses should be less than for the standard unit.

BLOWERS

Basically, inner-cooling derives its greatest value at higher gas pressures where the mass of the coolant readily may be balanced with the losses generated within the various components. In order to obtain greater mass flow, it is more desirable to increase the static pressure than the blower pressure because the blower losses increase directly with the static gas pressure, but increase as the cube of the gas volume through the system.

At any selected static gas pressure, however, there is an optimum blower design which is a compromise among high differential pressure, machine rating, and efficiency.

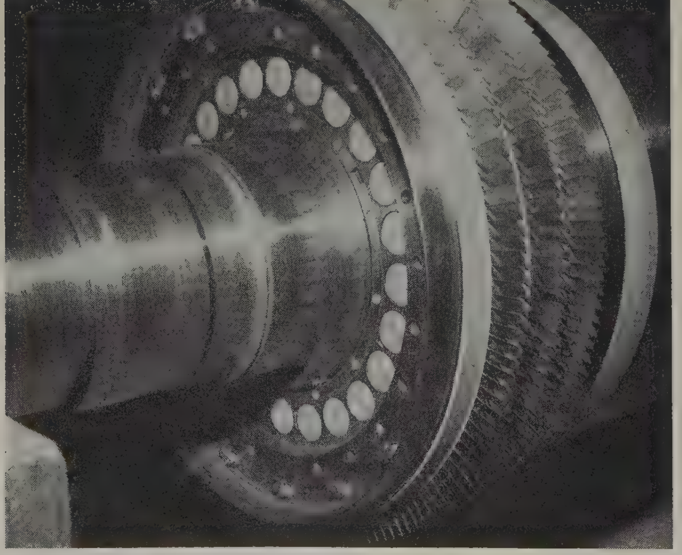
As discussed previously,[2] increasing the mass flow in conventional machines provides very little gain in rating so that high-performance blowers have not been developed previously for this purpose to any extent. On inner-cooled units, however, differential pressures are of direct benefit and merit exhaustive investigation. Advantage is taken, therefore, of compressor experience to produce blowers capable of high pressures at high efficiencies.

Multistage axial blowers currently are being applied to the inner-cooled generators in a form similar in principle to the 3-stage blower illustrated in Fig. 11. The actual con-

COOLERS

As a result of the higher gas temperatures, pressures, and velocities permissable in inner-cooled generators, the heat transfer rates on the gas side of the hydrogen cooler are increased so that it then becomes desirable to reproportion the cooler elements.

Studies have shown that the relations of cooler tubes and fins intended primarily for operation at the proposed pressures are considerably different from those required for operation in hydrogen at 0.5 psig pressure. By the utilization of smaller fin heights and pitch with appropriate tube diameters, it is possible to nest the cooling tubes into smaller cross-sectional areas. By this means it has been found practicable to construct coolers having less than 40 per cent of the working volume of a conventional cooler having the



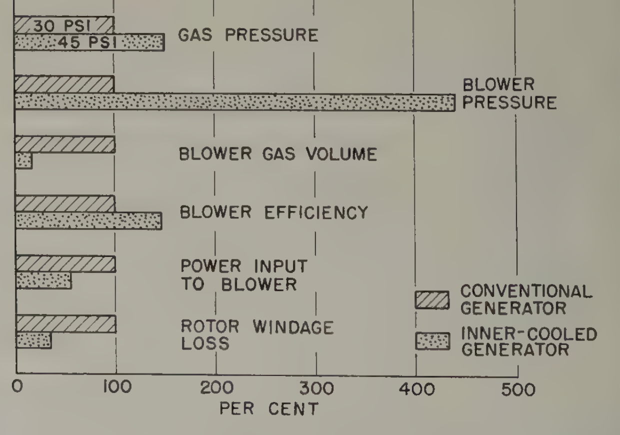


Fig. 12 (left). Assembly of rotor blades and hub for 3-stage axial blower. Fig. 13 (above). Comparison of windage losses for conventional and inner-cooled generators

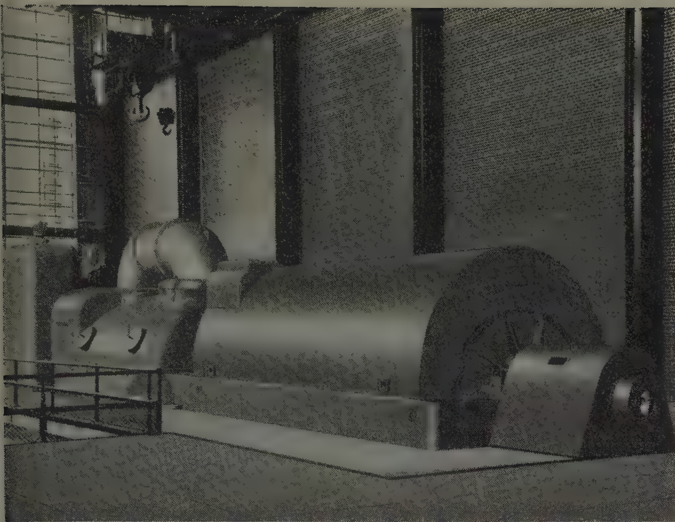


Fig. 14. Artist's conception of large inner-cooled turbine-generator installation

same heat-dissipating capacity without sacrificing any of the cooler performance. This construction yields a better relation between the cooling water characteristics and the hydrogen heat transfer surfaces for the intended application.

The new proportions, consequently, offer the possibility of a compact cooler arrangement which will be readily adaptable to the over-all generator construction previously described.

OPERATION AT HIGHER GAS PRESSURES

During the many years of successful practice, safe methods have been developed for the operation of hydrogen-cooled generators. As experience and confidence were gained, the operating gas pressures were increased gradually until there are now many machines in service operating satisfactorily at 30 psig.

The first inner-cooled generator will operate at 45 psig for its maximum capability rating of 100,000 kw.[10] During the shop test on this unit, several temperature runs were made at pressures of 96 psig. Such a pressure does not offer any particular problem from either the designing or operating standpoints. With the use of the heavier joints necessitated by the higher pressures, the gas leakage is reduced to a value comparable with that of present machines operated at 30 psig.

Improvements have been made in the gland seal in order to eliminate the friction between the seal rings and its housing produced by the higher gas pressures. Prolonged tests in the laboratory and on the inner-cooled generator have demonstrated that the new gland seal and joint sealing techniques are very successful. Consequently, it is possible to operate hydrogen-cooled generators at higher pressures with low gas consumption and with the same reliability as experienced on the low-pressure machines.

CONCLUSION

Inner-cooling of turbine-generator rotor and stator windings makes it possible to build machines of high specific ratings with moderate hydrogen pressures.

The reduction in the size of the rotor plus the reduction in the quantity of gas circulated through the machine permits the use of high-pressure blowers and results in windage losses lower than on conventional units. Maximum copper temperatures are the same as obtained on the standard windings while the average temperatures have been reduced. Refinements in the design of joints and gland seals result in lower hydrogen consumption.

The combination of blowers, coolers, and ventilation schemes lends itself admirably to the efficient and compact generator construction previously discussed and illustrated in Fig. 7. It also blends in excellently with the outer details of the turbine-generator unit to provide a pleasing over-all appearance as portrayed in Fig. 14.

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Nonheat-Vulcanizing Rubber

A new silicone rubber that vulcanizes at room temperature has been developed by Dow Corning Corporation. Identified as RTV (Room Temperature Vulcanizing) Silastic, it develops the high- and low-temperature stability, water repellency, and chemical resistance characteristic of silicone rubber within 24 hours after application. Neither heat, pressure, nor full exposure to air is required to cure sections up to 1/8 inch thick. Sections up to 1 inch thick may be cured under pressure up to 50 pounds per square inch, however, and curing time can be shortened substantially if heat is applied after the rubber has set.

RTV Silastic is available in several solvent-free consistencies, ranging from fluid enough to flow under its own weight to heavy enough to require milling. It is shipped and stored in the form of two separate components, each containing a catalyst. When the components are mixed in equal parts by weight, they react to form a nonheat-vulcanizing system. The material sets in approximately 4 hours, cures in 24 hours, and develops optimum properties in 4 to 7 days.

Its properties suggest the use of RTV Silastic as a cloth coating dope, a caulking, glazing, and sealing material, and a casting compound for flexible molds.

Developments in Armature Winding Arrangements

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NEW ELECTRICAL ARRANGEMENTS of armature windings have been developed to meet two separate challenges in the design of large turbine generators:

1. To make machines of a given rating physically smaller and greatly extend the possible ratings of the largest machine.
2. In the design of double-winding generators, to remove many restrictions of long standing.

The kva output obtainable from an armature of specified dimensions is limited primarily by the temperature rise of its windings. The largest component of temperature rise of the conductor in conventionally ventilated high-voltage armatures is the temperature differential across the ground insulation. Any mechanism which will reduce the voltage level for a given rating affords a compounded advantage—both current density and conductor cross-sectional area may be increased. The problem of reducing generator voltage is to obtain the minimum practical value of the ratio:

$$\frac{\text{Number of slots}}{\text{Number of parallel circuits} \times \text{number of phases}}$$

Both the number of slots and the number of parallel circuits per phase are subject to design limitations.

Multiple Circuit Windings. The number of parallel circuits per phase has been almost universally restricted so as not to exceed the number of field poles. This makes all parallel circuits identical, and thus avoids circulating currents between circuits.

Winding arrangements have been successfully devised for 3- and 4-circuit windings for 2-pole generators. The resultant gain in machine capacity is shown in Table I.

Table I. Kva Rating of a Particular Machine Size

Number of Circuits	Per Cent Kva
2	100% at 20 kv
3	113% at 15–17.5 kv
4	136% at 15 kv

Multiple Phase Windings. By the use of suitable windings on the step-up transformers, a multiple phase (6-phase, 9-phase, etc.) system of generated power can be transformed readily into a 3-phase system for distribution purposes. Table II shows relative rating and insulation voltage level for certain multiple phase arrangements applied to a particular machine size.

Digest of paper 54-42, "New Developments in Armature Winding Arrangements for Large Turbine Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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Table II. Multiple Phase Arrangements

	Per Cent Kva
3 phase–2 circuit	100% at 20 kv
6 phase–2 circuit	129% at 15 kv
9 phase–2 circuit	154% at 12 kv

Windings with increased number of phases show further increase in rating, but with diminishing returns considering the additional busses required between generator and transformer. With station design to minimize the length of bus run between generator and transformer, the 9-phase machine becomes competitive with multicircuit and direct-cooled designs.

Direct-Cooled Windings. The use of a gas or liquid coolant inside the ground insulation greatly increases armature capability.

Economics. There is a practical limit to the maximum rate-up that can be achieved without suffering a loss in efficiency. This point is beyond the capability of the low-voltage conventionally ventilated generators but within the ultimate rate-up of the liquid-cooled armature. Machine efficiency, first cost, operating cost, and maintenance should determine the best design (conventional, low voltage, or direct cooled) for a particular application.

A double-winding generator has two separate armature windings which, for the benefit of station circuit arrangements, can be loaded independently. The unique problems of this specialized machine are

1. Vibration caused by unequal loads on the two windings.
2. Rotor iron heating caused by unequal winding loads.
3. Through reactance must be high to limit single winding fault current.

The following double winding arrangements have been used: (1) alternate slot—coil sides of the two windings occupy alternate slots; (2) split-phase belt—each phase belt divided into two "subphase belts."

These two choices of winding arrangement have restricted the design of double-winding generators. A triple-split phase level winding pattern has been developed which adds greatly to the versatility of design. Table III compares old and new patterns.

Table III. Characteristics of Double-Winding Patterns

Desired Characteristic	Saturated Through Reactance (High)	Pole Face Loss (Low)	Vibration (Low)
Alternate slot	Prohibitively low	Very low	Low
Split-phase belt	Very high	Intermediate to high	Low to prohibitively high
Triple (or higher) split-phase belt	High	Low	Low

Determining Magnetic Wire Insulation Stability

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MANY HIGH-TEMPERATURE magnet-wire insulations are available which will meet initial design requirements and their suitability in this regard can be determined by comparatively simple and routine tests. Assessing the ability of such materials to maintain adequate properties throughout desired equipment life is somewhat more complicated. Consideration must be given to factors influencing deterioration and a criterion selected for the determination of insulation life. The most realistic results will be obtained when the material is tested in a configuration where the physical and electrical stresses are representative of those found in actual apparatus.

The test pieces used in this investigation consist of two insulated rectangular conductors which have been placed in a typical turn-to-turn relationship. During construction and treatment they are exposed to the mechanical and thermal stresses normally encountered in the manufacturing operations. The sample is small enough to represent a small section of a transformer winding with negligible thermal gradient. Thermal aging may be realistically accomplished in constant temperature ovens.

Reduction in dielectric strength of magnet-wire insulation in dry-type transformers during uninterrupted exposure to high temperatures may be used to define the insulation life which would be obtained with comparatively ideal operating conditions. The significance of dielectric strength criteria has been well established in other investigations[1,2] and it is feasible to make a large number of tests on small and relatively simple magnet-wire samples.

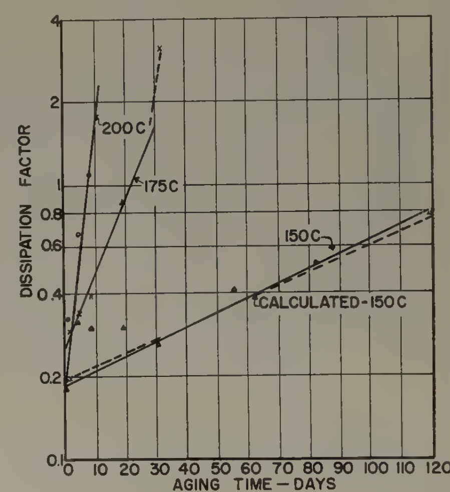
Dielectric and mechanical stresses normally encountered in dry-type transformers are comparatively minor sources of insulation degradation. However, when the material has deteriorated due to thermal aging, by flaking, crazing, or charring, it no longer provides the mechanical bonding or moisture resistance necessary for operation under adverse conditions. Insulation moisture resistance as determined by dielectric loss measurements after humidification will serve as a criterion for determining the ability of a material to withstand such operating hazards as moisture absorption and mechanical shock.

Results have been obtained which indicate that the deterioration rates measured by reduction in dielectric properties at high temperatures may be verified experimentally at lower temperatures. A linear relationship is apparent in Fig. 1 between *ln* dissipation factor and aging time at each temperature. It has been shown[3] that such a relationship between the logarithm of the pertinent physical property and aging time is indicative of a first-order chemical reaction. In that event

$$\log D = B - At\epsilon^{-E/RT} \qquad (1)$$

where D is the dissipation factor after humidification, B establishes the level at zero time, and A and E/R are constants which may be calculated from the data obtained at accelerated aging temperatures. These values may be used in turn to determine the relationship between dissipation factor after humidification, and aging time at some lower temperature. In Fig. 1, the 150 C curve calculated from

Fig. 1. Relationship between dissipation factor of humidified sample and aging time at high temperature. Data are for an acrylic ester resin impregnated asbestos-clay sheet, covered with glass yarn and phenolic varnish treated



the data obtained at 175 and 200 C agree very well with the experimental 150 C curve.

CONCLUSIONS

1. A test method has been developed for the evaluation of high-temperature magnet-wire insulation which may be used to determine insulation life under both ideal and very severe service conditions. Consideration then may be given to a variety of service requirements in the interpretation of aging results.

2. Deterioration rates for a given material as calculated from measured reduction in dielectric properties at high temperatures may be verified experimentally at lower temperatures. Justification is provided thereby for the extrapolation of data to lower operating temperatures.

3. Caution should be observed in extrapolating to lower temperatures data which do not indicate the presence of the same deterioration mechanisms at different accelerated aging temperatures.

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Research for and by the Electric Power Industry

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Although the electrical utility industry has made an outstanding record in meeting the demands of its customers for electric service and the future seems extremely bright, the collective research effort of the industry does not appear adequate to insure its future against possible inroads of competition from other forms of energy delivery, possible new developments, and from encroachments by government. A broad program of basic research, conducted on a co-operative basis to supplement the existing research conducted by the manufacturers and the utilities themselves, is recommended strongly as a means of insuring the industry's future.

THE SUPPLY of electric power to thousands of American businesses and millions of American homes represents an outstanding record of accomplishment. It is a record achieved largely through technological developments of the last 125 years, beginning with Faraday's discovery of induction and continuing through the introduction of the transformer, the invention of the electric light, and the development of rotating machinery. Certainly it is a productive and virile history. The electric power industry in the United States supplies today over 340 billion kilowatt-hours (kwhr) annually, a total of more than 2,200 kwhr for each person. The rapid growth of electric energy production is well illustrated by Fig. 1.[1] The output of electric power doubled in the decade from 1931 to 1941, doubled again from 1941 to 1951, and system load forecasters are using a long-range trend which averages 5 to 6.5 per cent growth per annum compounded.[2]

J. H. Foote at the June 1952 convention of the Edison Electric Institute said:

"In the face of a rise in taxes from 17.7 per cent of revenue in 1940 to 23 per cent at the end of 1951, of an increase in the hourly rate of pay including cost of fringe benefits to about double that in 1940, and of an average rise in cost of coal from \$3.40 to \$6.05 per ton, the average price per kilowatt-hour sold to the residential customer dropped from 3.84 cents in 1940 to 2.81 cents in 1951."

The householder's dollar of 1939 buys \$1.45 worth of electricity today, and 40 cents worth of food.

The importance of electric energy to industrial life is made very vivid by H. H. Rogge. He estimated the annual output of physical energy made by the average working man, working an 8-hour day, for 240 days per year, at 77 kwhr or about 103 horsepower-hours. The average worker with reasonable exertion can produce at the rate of only about 1/25 of a kilowatt or a little over 1/20 of a horsepower.

This unit of annual output per man, equivalent to 77 kwhr, Rogge calls an enerjoe, a word derived from energy and Joe (the average man).* With a consumption of approximately 340 billion kwhr of electric energy annually, equivalent to 4.4 billion enerjoes, it would have taken 4.4 billion workers—nearly $1^1/_2$ times the population of the entire world—to have provided that much energy. With this interesting concept, the electric power industry provided 29 hard-working enerjoes for every man, woman, and child in the United States; 29 servants who require no sleep, rest, food, recreation, or pensions; 29 helpers with push-button control; 29 slaves who never mutiny, except for short periods in most unusual circumstances of lightning storm, sleet, fire, flood, hurricane, or earthquake. The electric power industry is largely responsible for our high schedule of productivity, our high levels of income, and our high standards of living. It is a glorious history, indeed, with apparently a glorious future.

A LOOK TO THE FUTURE

YET is the glorious future assured? The head of the electrical department of one of the leading engineering educational institutions recognized fully this accomplishment in a recent private communication but stated, "I want to know more firmly than I know now whether it has a glorious future." Undoubtedly his outlook is based on the uncertain prospect, as he sees it, for further scientific and technical accomplishment, and the industry's failure to challenge superior scientific and engineering talent and to attract the more able young engineers and scientists. There is much current evidence to support his view, but his pessimism is not shared by the authors. It is felt, however, that it is time for the industry to take a good look at its technical self and to build a new frame of reference for the future. Therefore, it is well to consider the following aspects of the electrical utility industry:

1. It has depended on European discoveries and technology for many of its developments, not only for more

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The authors wish to acknowledge the assistance of several members of the staff of Stanford Research Institute, particularly W. B. Gibson, R. W. Smith, and C. X. Larrabee.

* "The Wonderful Powerful Enerjoe," address by H. H. Rogge, president, Canadian Westinghouse Company Limited at the Director's Luncheon, Canadian National Exhibition, September 1, 1953.

fundamental and basic principles but also for certain equipment developments.

2. Scientific and technical leadership for the industry in the United States has resided for more than 50 years in the laboratories of a very few large manufacturing suppliers. This situation has desirable features, but means that the industry has developed largely through the leadership of the equipment manufacturers. Great credit must be given to the laboratories and staffs of these manufacturers. The entire profession of applied research is indebted to the General Electric Company Research Laboratories for developing the powerful method of applied research—the organized teamwork approach responsible for so much of the industrial development of the United States. This laboratory, established about 1900, set the pace and pattern for the powerful, unique, and vital industrial research system of the country. General Electric, Westinghouse, Allis-Chalmers, and others have done outstanding work for the continuing good of the industry and the public, and have contributed generously to the education of young engineers and scientists through fellowships, the National Science Talent Search, foundations, gifts of equipment, and the support of research in colleges and universities.

3. Lacking the freedom of competitive industry to seek higher profits, but with persistent pressure for lower costs, the utilities—with several outstanding exceptions—have given too little consideration to their public responsibilities as regulated monopolies to develop the industrial and economic levels of the areas they serve. This is a major point for immediate concern.

4. Much of the research and development effort now made by the industry is for marginal improvements in efficiency of equipment and plants, and there seems to be insufficient long-range broad-based imaginative research directed toward new sources of power, wider use of electric energy by the public, and the possibility of still lower costs. Significant investments now are being made, of course, in the nuclear power programs.

5. Electrical utility publications are filled with articles on sales promotion techniques and the threat of government competition. Seldom is the word "research" used in accounts of action or planning by the electrical utilities, yet the industry is based on technological developments.

6. The federal government has sponsored little research and development in or for the electrical utility industry in comparison with federal support for electronics, aeronautics, or atomic energy.

Additional research activity in the electrical utility industry undoubtedly would offer an additional inducement to attract the best young technical men into the industry and to hold their interest in the face of competitive opportunities.

THE NEED

These statements may be controversial, but it is believed they can be supported by conditions within the industry. It is a logical inference that the electric power companies should undertake a much broader and more aggressive research program directed toward protecting their future. One may ask why the power companies should be urged to do this. Public utility executives frequently have been heard to state that the business of their companies is to generate and deliver power, not to become immersed in details of apparatus improvement which are the province of their suppliers. Nevertheless, it is believed that the power companies should not leave the task to others but should participate themselves, either directly or through co-operative agencies they sponsor and direct.

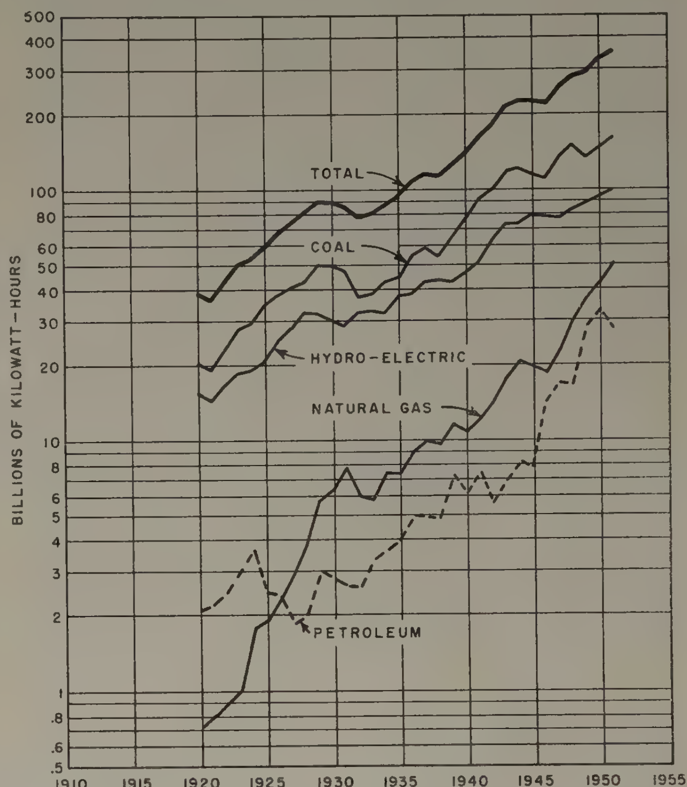

Fig. 1. Sources of electric energy in the United States. Data are the actual amounts of electric energy produced from each source. The electric energy produced from coal has a higher growth rate than coal consumed in coal steam-electric plants because of increases in operating efficiency. Sources: Consumption of Fuel for Production of Electric Energy and the 1951 Annual Report, Federal Power Commission

If the lessons of the industrial age teach anything, they show that the only real insurance for future security is research and development directed toward preparation for that future. It is suggested that the industry, even though it is operated as a regulated monopoly without direct competition and with ever-increasing demand for its services, cannot disregard this lesson.

Further, it is strongly believed that there are challenging and rewarding opportunities in the power industry to interest the best brains in both scientific and economic research. It is believed that the only effective way to meet competition from either alternative power sources or from unnecessary government operations is to seek broader application of electric energy at lower cost.

AN EXAMPLE

Perhaps an example from another industry will illustrate the possible hazard to the power industry. The railroad industry of this country, also a public service regulated monopoly, was in a very favorable position during the early part of this century. The extensive facilities were excellent, there was little or no competition, and earnings were good. Yet almost overnight rising costs for labor, higher taxes, and the development of the internal combustion engine, leading to strong competition from the highways, changed this outlook substantially. The situation worsened following World War I, was made even more grievous and acute by the rapid development of aviation and by government subsidy of various transportation services, and the depression in the 1930's forced a number of railroads into receivership and bankruptcy.

Until this situation had become acute, almost all of the research, development, and scientific activity of the railroad industry was centered in the manufacturers of railroad equipment and supplies, who had entered into an era of stabilization with a lack of imaginative technical progress. Much could be said about the absence of any major improvement in motive power, roadbed, and freight and passenger cars, but it may serve the point merely to recall the quip that the only improvement in Pullman cars for the 25 years after 1907 was the addition of the slot for used razor blades.

Now the situation is changing. Although most of the railroads have not built sizeable research and development departments of their own, they are supporting research, and have created a common research front through the Association of American Railroads, with research laboratories in Chicago, Ill. A current research budget for the laboratories and contract research of approximately $1 billion, for an industry whose gross income is nearly $9 million, is very small. But the program, directed toward establishing equipment requirements, specifications, and limitations, toward evaluating conditions of service and developing acceptance tests, and toward a basic study of fuels, lubricants, packaging, and logistics is expected to grow to perhaps ten times the present figure and to exert a major force on solving the industry's problems.

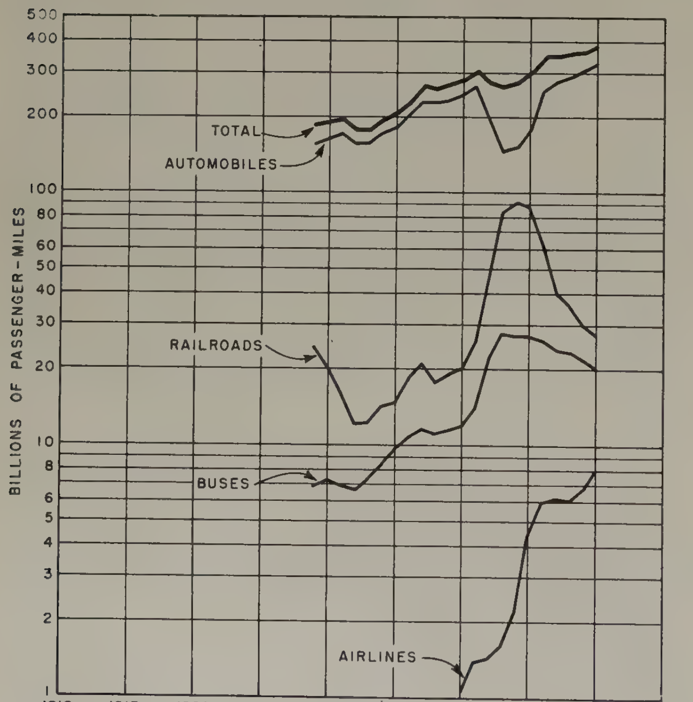

Fig. 2. Intercity passenger transportation in the United States. Other types of intercity passenger travel such as motorcycles, private airplanes, all forms of water transportation, and interurban electric railways not included. Source: Annual Reports, Interstate Commerce Commission

Forced by competition, high labor costs, and high taxes to seek new methods, the railroads have recognized their critical need for increased technological developments, for providing better service, and for the guidance of sound economic research. Increased research activity has been accompanied by increased vitality in the industry, by the attraction of more competent technical and management skills, and by greatly increased research activity on the part of large manufacturers such as Pullman Standard Car Manufacturing Company, Budd Company, and American Brake Shoe Company. The introduction of the diesel engine, many improvements in rolling stock and roadbed, and technical studies of many factors leading toward improved service have made it possible for the railroads to operate effectively and usually at a profit, in spite of reduced volume and strong competition.

The railroads also are becoming active in economic research as an aid in industrial plant location studies, and in developing latent resources for the regions they serve. It would appear that economic and other fact-finding studies directed toward the creation of new industries, higher levels of income, and development of natural resources are more effective load-building than sales and promotion campaigns alone—and certainly a more significant contribution to the public interest.

The comparison of railroad volume with that of competing forms of transportation is shown for passengers[3] in Fig. 2 and freight[4] in Fig. 3. The long-term trend appears to be a gradual rise from depression lows but every effort still is needed to restore the industry to sound economic health. The railway industry has acknowledged its need for an essential step in regaining financial stability, and already is receiving substantial benefits.

THE ANALOGY

Returning to the utility industry, is not the situation similar to that of the railroads half a century ago? What is the competition it faces today? First and foremost the electric power industry is not itself a producer of energy, but rather an agency through which energy in another form is delivered as electric energy convenient to use and permitting instant, effective control. The same amount of energy can be obtained through direct access to falling water, or by the direct combustion of fuel. Hence the value of the industry lies only in the economy and convenience of its conversion and delivery service. Competition may arise from every other form of energy delivery, in particular, direct delivery of coal, oil, and gas.

Everyone is aware of the competitive position of gas in

residential and industrial markets. Natural gas can be transported 2,000 miles or more and still compete effectively; the rate of new discoveries shows little immediate prospect of diminishing. For 3 decades the new discovery rate has been above production by two or three times. For bulk energy transmission, electric transmission is generally more expensive than transmission by oil or gas pipe line, or even coal transmission by barge.

The possibilities of competition from nuclear fission remain unknown. However, experience should lead everyone to expect major technological developments. At present, nuclear fission appears to have promise as an economical source of energy only as a large-scale enterprise, supplying power to electrical utilities for transmission to ultimate customers. Nevertheless, it is by no means beyond the realm of possibility that smaller package units operating from atomic fuel could, and perhaps will, supply all the energy needed in a household or small region for many years without care or replacement. The only certainty is that there will be technological developments in the field of nuclear energy and that they may demand important changes in the present system of energy supply. The industry must be in the forefront of the new technology.

A threat to the electric power industry already exists in competition and encroachment by government. The percentage of publicly owned generating capacity in this country has increased three or four times since 1920. The federal government now produces about 12 per cent of the energy generated for public supply. But today private electrical utilities are finding a favorable attitude in government for the first time in 20 years, and the opportunity must not be lost. The administration has made it clear that the big challenge to private utilities is to provide additional energy without increasing real costs per unit of service.

The industry has been criticized because it has not expanded capacity at a sufficient rate (alleged inadequate planning and forecasting), and because its costs are still too high. It is expecting too much that adverse public reactions, created by government and political attitudes over many years, will be eliminated overnight. To regain public confidence the industry should assume an aggressive role on all fronts, technical as well as legislative. The public relations value of research has not been utilized fully.

Public utilities, as protected but regulated monopolies, have a direct responsibility to the public to seek every means for improving efficiency and reducing costs. It is incumbent upon the utilities to seek basic methods to improve their operations by exploring new energy sources, new techniques, and by long-range planning in search of new methods to reduce costs. Although much is being done in this area, it seems fair to say that these efforts are devoted almost exclusively to immediate results, and that little technical effort or research is being devoted to long-range operations in the fields so necessary to healthy survival.

A RESEARCH PROGRAM

A PROGRAM of research for the utility industry, to be effective, must be broad and comprehensive. What research should be undertaken cannot be stated in a single definite answer, but must be evaluated continuously, and the whole program must have a continuing place in the policy thinking of power company managements. However, certain fields of research can be suggested.

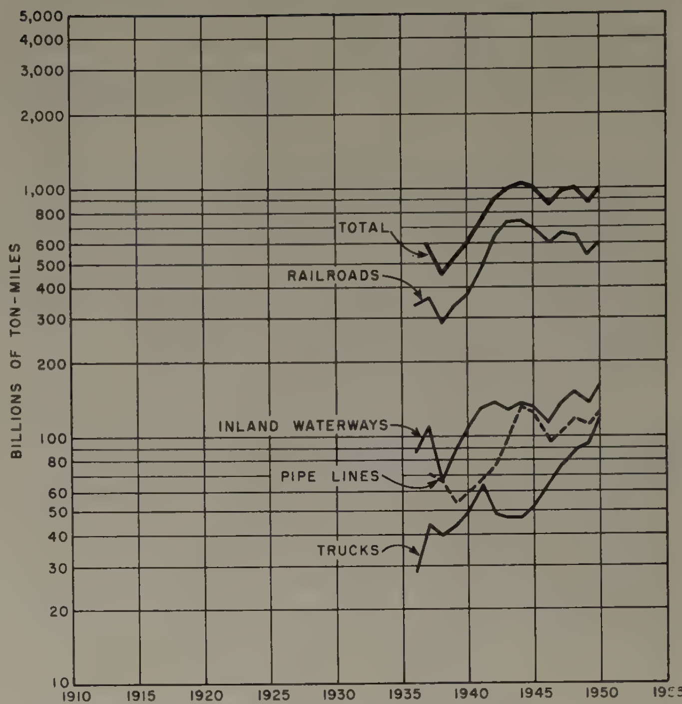

Fig. 3. Intercity freight transportation in the United States. Pipe lines: only those carrying oil; railroads: both steam and electric; the total includes air freight, which increased from 8 million ton-miles in 1936 to 306 million ton-miles in 1950 but is still below the limits of the graph. Source: Volume of Intercity Freight Traffic, Statement 5046, September 1950, and Monthly Comment on Transportation Statistics, October 12, 1951, Interstate Commerce Commission

Basic research, primarily of a long-term nature, is needed. Of great importance is a comprehensive study of materials. The electrical utility business is vitally dependent upon insulating material, solid, liquid, and gaseous. In spite of many studies, the basic behavior of such materials is still largely unknown. Although the manufacturers have done much research, particularly on solid and liquid dielectrics, the objective has been the development of materials which will have competitive advantages. More fundamental studies should be aimed at understanding the reasons for the behavior of dielectric materials. Some work also has been done on gaseous insulation and on the properties of air. Nevertheless, altogether too large a portion has been devoted to obtaining empirical results for immediate application, with less emphasis on the physical, chemical, and basic properties. Most of the work done on the subject of corona has been empirical in nature, and many of the factors influencing corona still are unknown or unexplained.

In the area of conducting materials, the field is more limited, as only copper and aluminum appear to have promise as conductor materials of sufficiently low cost to find extensive application. Undoubtedly there is room for important work in materials for special applications,

such as contacts, and conductors subject to damage from fumes, atmospheres, or liquids.

Great strides have been made in developing improved magnetic materials. Their importance fully justifies further study and an intensive effort to understand more completely the principles and properties of magnetism.

In the area of structural materials which are not depended upon either for conducting or insulating properties, the electrical industry finds common ground with many other industries. Applications for materials with special properties, in such fields as nuclear power, gas, and steam turbines, well may call for important studies.

The electrical industry is uniquely dependent upon the phenomena of switching, opening, and closing circuits. Yet, the electric arc and electric discharges in gases, liquids, and solids are only partly understood. Great advances have been made in arc interruption, but the improvements are largely empirical, rather than truly scientific.

All electric power of commercial importance is converted from mechanical energy to electric energy in a generator that depends upon Faraday's discoveries of electromagnetic induction. Other forms of energy conversion are known, but little has been done to investigate their properties. It is not now evident that other processes are commercially valuable, but they should be better understood, and their economics reinvestigated from time to time to guard against unpleasant surprises. Electrochemical energy conversion has its important place in batteries, and while much has been done to investigate other materials for batteries, the power industry has had a relatively small part in the work.

Another broad area for research involves obligations to other industries, organizations, the public, or government. Obvious examples are the problems of radio influence; stream and air pollution; and irrigation, navigation, and fish life in connection with hydroelectric projects. Some co-operative work has been done but the effort has been limited.

The program must consider the relations of the industry with its own employees. In particular, as has been pointed out, there is growing evidence that the established engineers in the industry, highly individualistic, and resisting union regimentation, have not received adequate recognition.

Many basic problems of existing systems only partially are solved, and the industry as a whole would benefit by concentrated effort. Examples include improvements in fuels and combustion, heat transfer, cavitation in hydraulic turbines, and interconnected operation of systems, interrelated with frequency and load control. Better co-ordination of plant operation is desirable, to obtain the best utilization of existing resources.

The days of overhead distribution, and even transmission, may be limited. Overhead lines are cheaper today but have serious limitations of weather vulnerability, right-of-way requirements, and unsightliness. Efficient use of manpower is difficult, and maintenance costs seem unduly high. If a vigorous and comprehensive research program in underground transmission and distribution were pursued for new materials, new techniques, mass production, and for the development of machinery for field installations, much lower over-all costs, possibly even competitive with overhead construction, probably would be obtained. Any difference may be more than offset by the good will engendered.

The previous suggestions are primarily technical. In addition, there is a vast area for research primarily in the economic field. Much attention now is being devoted to a comprehensive study of system losses, looking toward greater economy in system loading and dispatching. This is only one aspect of the field that is being recognized as operations research, and clearly work in this area should be expanded greatly. The unique feature of operations research is that the objective in each problem is to find optimum conditions to maximize or minimize a variable; for example, costs, profits, efficiency, or capacity, expressed by a mathematical model. This situation exists in the electrical utilities, but the powerful and effective tool of operations research has not been used to any extent in the industry. Most applications of electronic and mechanical computers within industry must be preceded by an operations analysis. These, it is believed, are tools of real promise.

Attention should be devoted not only to the economics of existing systems, but even more to contemplated additions and forecasting of future loads. The use of automatic computers readily suggests the possibility of continuous studies of present and future loads, leading on the one hand to automatic dispatching for maximum economy and, on the other, to machine calculations of load forecasts. The use of automatic machines for accounting, billing, and economic analyses already has begun. Development of better, faster, and cheaper machines and their more widespread use are essential.

A program such as this cannot be organized at once, and it hardly could be carried out by any single utility company or even a limited group of such companies. The problems are industry-wide, and such a program probably can be carried out best by co-operative action, co-ordinated with the existing research of the manufacturers and the individual utilities themselves. Broad basic research should be carried out under the auspices of an association established with research as one of its main objectives. All utilities, both public and private, are interested in the results as well as the manufacturers. The existing industry associations could be expanded for the task, or a new organization might be formed. In any case, the research program should be organized so that continuous contact is maintained between the active research organizations and the operating companies. Although it is important that basic research be isolated from the day-to-day problems, it must not be conducted in a vacuum—without contact with the reality of the purpose it ultimately must serve. In other industries, joint steering committees representing broad interests have been effective in guiding basic research. It is believed that this approach would prove effective in the electric power industry.

Some fear has been expressed that an industry-wide association of this kind might encounter legislative difficulties from the antitrust laws or other restrictive legis-

lation, but limited experience in the industry and similar experiences in other industries, including the railroads, do not support this fear. It is unlikely that a program so obviously in the public interest would encounter any major or sustained opposition in Congress or from the courts, and it certainly deserves the fullest support of the utility commissions.

In embarking on such a program effective use should be made of all existing facilities. Colleges, universities, and independent research laboratories and foundations are well constituted for some of the basic studies. The spreading of power company research into college channels on a sponsored basis will have a salutary effect on the morale of faculty men interested in the power field, and will do much to arouse the interest of students. The possibility of employment in industrial research laboratories or in research and development departments of utility companies having a strong program of challenging problems can help reorient the employment trend.

The cost of such a program would not be excessive. Many an industry today that values its future, invests from 1 to 5 per cent of its gross income in research and development. For the power industry an additional investment of perhaps $5 million annually would not solve these problems the first year, but in several years such an investment in joint research, would go far toward charting a sound future. Yet $5 million is not 1 per cent nor even 0.1 per cent of the gross electrical utility income of the class *A* and class *B* privately owned utilities. It is believed that the industry cannot afford to take the chance that someone else will guard its future, when a good brand of insurance is so definitely within its resources.

SUMMARY

IN SUMMARY it is suggested:

1. The electrical utilities should undertake increased research effort, both scientific and economic, to maintain and improve their competitive position (real and potential), to reduce costs, to aid in building loads, to provide a basis for adequate forecasting, and to meet their public responsibilities.

2. Research in the electrical utility industry should not replace, but should supplement and complement that done by the manufacturers and suppliers of electric equipment and appliances.

3. An industry-wide additional annual budget for joint co-operative research of perhaps 0.1 per cent of gross electrical utility income (in the order of $5,500,000) would not seem inappropriate when compared with other industries.

4. Utility research effort should be balanced among:

(*a*). Research done in the individual utility company laboratories by their own staff members.

(*b*). Research in the laboratories and by the staff of an association representing all of the utility industry (similar in purpose to the laboratories of the Association of American Railroads, the Institute of Gas Technology, the Institute of Paper Chemistry, and many others for particular industries).

(*c*). Research conducted in colleges and universities, private laboratories, and public service laboratories available on a sponsored basis.

5. The research effort also should be properly balanced among:

(*a*). Long-range and short-term objectives.

(*b*). Scientific, engineering, and economic studies.

(*c*). Individual company and industry-wide interests.

6. Consideration should be given to the public relations and public obligations aspects of research:

(*a*). In technical areas such as radio influence, air pollution, water supply, hydroelectric development, irrigation, etc.

(*b*). In economic areas such as studies of new industry location, the development of regional resources, economic forecasting, etc.

7. Every effort should be made to utilize this program to improve the scientific manpower situation by:

(*a*). Providing stimulating problems within the industry.

(*b*). Encouraging college and university faculty members to study the industry's problems.

(*c*). Demonstrating to students that the industry has interesting work to do.

It is felt that the time to begin such a program is now, before unexpected contingencies have cast any clouds on the glorious future being predicted so readily on every hand.

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3. Chemical Economics Handbook. Stanford Research Institute, Stanford, Calif., 1954, p. 294.30.

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Four-in-One Engine Generator

An engine-generator set that will do the work of four has been designed by the Engineer Research and Development Laboratories, Fort Belvoir, Va.

Now being procured in quantity in 3-, 5-, and 10-kw sizes, the new sets are destined to simplify the stockpiling and issue of sets in this size range, which are among the most widely used in the U. S. Army.

With a simple, foolproof adjustment, one engine-generator set can be made to supply four different types of electric power for which separate sets were formerly required. These are 3-phase 4-wire 120/208-volt; 3-phase 3-wire 120-volt; single-phase 2-wire 120-volt; and single-phase 3-wire 120/240-volt power. Full rated output is available with any of the four connections.

In a simple operation, link positions are changed on a reconnection panel located on the side of the generator to supply the different voltages and phases. The load terminal plate shows the operator which terminal is electrically energized for wire connections.

Stator Insulation for H-V Inner-Cooled Generators

G. L. MOSES
FELLOW AIEE

INNER-COOLING of high-voltage generator stator coils has made possible greatly increased ratings for the magnetic and conductor materials in large hydrogen-cooled machines. This has required modification in some insulation design practices and application methods.

Generators with inner-cooled stators are of sufficiently large rating that single-turn stator coils are used and the problem of turn insulation is nonexistent. One new element has been added to the stator coil of an inner-cooled generator. This is the metal tubes which carry the cooling gas within the stator coil. The outside surfaces of these metal tubes must be insulated electrically from the conductor strands, and each other, while maintaining intimate thermal contact with the strands.

Thermalastic insulation is employed and normal generator insulation design practices and insulating techniques are completely applicable to stator coil major ground insulation.

In the end windings where the stator half coils are connected, it is necessary to leave the ventilating tubes open for access to the cooling gas. The conventional taped insulation cannot be applied to the complete coil-to-coil connection as on a conventional hydrogen-cooled generator. To insulate the connections between half-coils, a special molded silicone rubber cap is applied. The joints between caps and coils are taped with conventional insulating tapes. A completely insulated coil connection results with a high dielectric strength barrier everywhere except at the point where the metal vent tubes extend into the cap openings.

The voltage of each coil appears at the coil ends on the metal ventilating tubes. Therefore, it is necessary to provide adequate striking distance from the tube ends and the supporting insulating cap to adjacent metal parts.

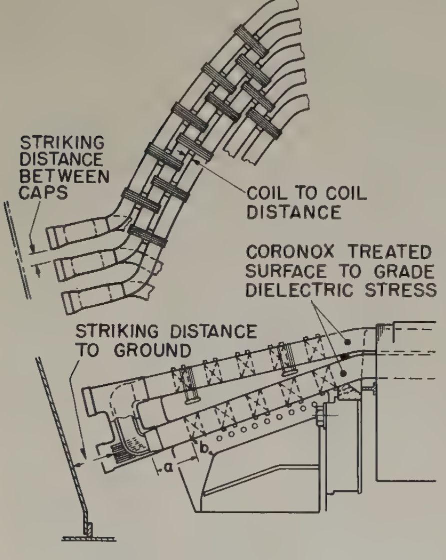

Fig. 1. General construction of stator end windings, insulating caps, and coil supports of an inner-cooled generator

Fig. 1 shows the general arrangement of end windings, caps, and coil supports on an inner-cooled generator. Distances must be adequate to assure that no corona will occur which might lead to failure.

The following objectives were chosen for establishing insulation withstand test levels.

1. Ample margin must be provided in insulation levels for all operating and test conditions required by American Standards Association (ASA) standards.
2. The insulation must be capable of safe, reliable operation under likely abnormal service conditions.
3. The insulation must withstand occasional overvoltages within the limits of the protection provided by conventional surge prevention means.

The following test limits were established:

1. The windings together with creepage and striking distances shall be capable of withstanding short-time overvoltage tests at 25 per cent above the acceptance test levels required by ASA standards, when tested either in air or in cooling gas at the rated operating pressure.
2. The windings shall be essentially corona-free at voltages substantially above operating conditions.
3. There shall be no visual corona at the exposed vent tube ends under the conditions of the final acceptance test.
4. The impulse level of the windings shall be at least 25 per cent greater than the peak of the 1-minute ASA dielectric acceptance test.

Existing practices of the most modern insulation are well adapted to inner-cooled stator coils. There is no turn-to-turn problem, as all coils are single turn with complete ground insulation on each. Conventional strand insulation is used on the conductors. The metallic ventilating tubes are comparable to strands and can employ conventional strand insulation. These metal vent tubes leave the conductors only in the extreme ends of the windings far removed from the core and coil supports. They are covered with insulating caps applied with conventional tape sealing further to improve factor of safety. The ground insulation is standard Thermalastic, which has proved very satisfactory over the last several years. The dielectric stress that exists between the ends of the tubes and metallic parts, either through gas or over creepage surfaces, can be taken care of adequately with suitable spaces to make the windings essentially corona-free and completely reliable.

Digest of paper **54-18**, "Stator Insulation Practices for High-Voltage Inner-Cooled Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, February 1954, pp. 36–9.

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Tellurium Alloy Lead Sheath for Power Cable

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DURING RECENT YEARS there has been a pronounced increase in load requirements and operating temperatures of power cable systems. The accompanying increase in cyclical expansion movement of cable in underground ducts has placed such a severe bending burden on ordinary sheath, such as copper bearing, that sheath life no longer can be co-ordinated with insulation life. Alloy sheaths with greatly improved bending fatigue resistance are a solution of this problem.

Improved long-time creep resistance is equally, if not more, important. Modern solid-type cable tends to build up relatively high internal pressures during load cycles, due to compound migration on slopes. With oil-filled cable it is desirable to reduce the number of stop joints required to break up head pressure on rugged profile. High-creep-strength sheath is even more important for low-pressure gas-filled cable. Increased working gas pressure means a corresponding reduction in insulation thickness, cable size, and cost, with pronounced economy.

With the preceding goal in mind the authors' company started an intensive research program over 8 years ago. Systematic studies were made of the properties of several hundred alloys of lead. This was made possible by developing methods of extruding miniature samples in the laboratory that closely simulated full-size sheath production in the factory. Special methods of test for ready evaluation also were developed. After exhaustive search it was found that an alloy of lead containing tellurium, arsenic, and tin; or tellurium, arsenic, tin, and bismuth; had outstanding long-time bending and creep properties. It also was found to have a wide latitude for heat treatment during factory extrusion operations with standard lead press equipment. Heat application in the field at joint end wipes and other locations does not affect its desirable properties.

Table I shows the excellent bending strength of tellurium alloy in comparison with other generally used lead sheathing materials. These results have been confirmed by cable

Table I. Bending Life Constants for Several Types of Lead Cable Sheaths at 110 F, and 1 to 20,000 Bending Cycles Per Day

Material	Strain = 0.6% *b**	Strain = 0.6% *m**	Strain = 0.3% *b**	Strain = 0.3% *m**
Acid lead alone	640	0.69	710	0.66
Chemical lead alone	630	0.67	730	0.63
Corroding lead alone	880	0.72	980	0.70
Common lead alone	610	0.67	720	0.66
Te-As-Sn alloy	4,400	0.81	9,600	0.83
Te-As-Sn-Bi alloy	2,400	0.81	8,800	0.83
As-Sn-Bi alloy	2,550	0.87	4,200	0.80
As-Sn-Bi-Cu alloy	1,300	0.71	3,400	0.70

* Constant *b* equals bending life in days at a frequency of one cycle per day. Constant *m* represents the slope of a straightline log-log plot of bending life in days versus frequency of bending.

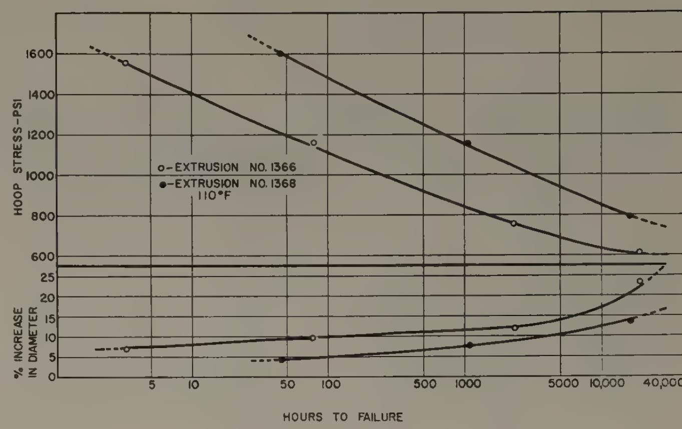

Fig. 1. Bursting strength and ductility of tellurium alloy sheath tubes as function of time; extrusions number 1366 and 1368

"U" bend tests, and by dummy manhole tests carried out by the Commonwealth Edison Company.

Long-time creep tests have been completed on a large number of samples, made in the laboratory, and also prepared from factory-produced cable sheathing, at room temperature, 110 F, and 150 F, over a range of stresses. The results show tellurium alloy to have outstanding creep strength, materially exceeding that of any cable sheath alloy now in use. The final yearly creep rate of this alloy has been found to average only 0.015 and 0.35 per cent at 110 F, 200 and 300 pounds per square inch, respectively. At 150 F, the corresponding yearly creep rates are 0.09 and 0.60 per cent, respectively. When maximum creep rate is desired, the best results are obtained with tellurium alloy sheath quenched at relatively high temperature during sheath extrusion. Low-temperature quenching will give excellent creep strength results.

Fig. 1 covers 110 F hydraulic time-rupture tests on sheath tubes from which the cable core had been removed. This test, being carried out by the Philadelphia Electric Company, has extended to $2^1/_2$ years and still continues. The excellent long-time strength and ductility of tellurium alloy, both "hard" and "soft," is shown and confirms the creep strength results described in the preceding paragraph. The only difference between the "hard" and "soft" alloys is represented by the wide range of quenching temperatures employed during production.

Since completion of tellurium alloy, commercial orders of cable with this type of sheath have been produced. This practical experience confirms the development results outlined.

Digest of paper 54-7, "Tellurium Alloy Lead Sheath for Power Cable," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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The Electroluminescent Lamp: A New Light Source

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THE RECENT development of a practical electroluminescent lamp has aroused great interest because of some unusual characteristics of this new light source. First, it is a 2-dimensional source, emitting light of uniform intensity over an extended area, with the thickness of the lamp being less than $^1/_4$ inch. Second, because of its unique construction, the life of the lamp is not ended abruptly. There are no filaments or cathodes to fail, no vacuum to be maintained, and no effect of ion bombardment with which to contend, so the end of life is determined only by deterioration to a brightness too low to be useful. This may take 10,000 hours or even longer. These important new features make it desirable to gather together the scattered technical information into a comprehensive summary.

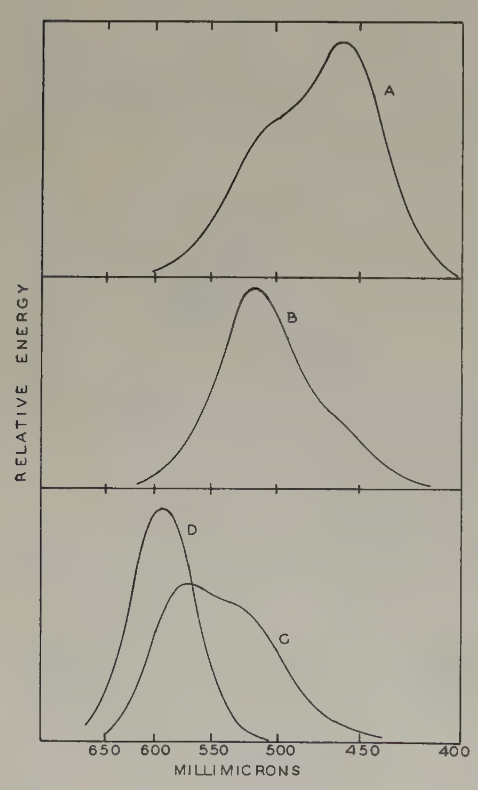
Important characteristics of electroluminescent lamps are presented together with the most plausible mechanisms of electroluminescence and the three general types of applications.

BASIC PRINCIPLES

IT was observed by Destriau[1] that some phosphors could be excited by the application of an alternating electric field, but the amount of light he obtained was apparently very low.[2] In 1950, Payne, Mager, and Jerome[3] published data on the initial development of a practical electroluminescent lamp. This development has been carried considerably further in the past 3 years and much technical data obtained.

In its present form, the electroluminescent lamp can be described briefly as a flat-plate luminous capacitor. It consists of a sheet of conducting glass coated with a thin layer of a special phosphor dispersed throughout a solid dielectric. The phosphor-dielectric layer is coated in turn with a metal foil, usually a film of vaporized aluminum. Lead wires are attached to the conducting surface of the glass and to the metal foil, thus completing the capacitor. The aluminum foil then is coated with a clear lacquer and a high melting wax and covered by a second sheet of ordinary glass or a plastic or metal case. In some types of lamps, the thickness of this sandwich is reduced, by omission of the wax and the second glass sheet, to give an appreciably thinner construction.

While the lamps now being produced are designed as flat plates to be operated on 60 cycles at either 120 or 600 volts, there are few limitations on voltage or frequency and the lamp can be made curved in at least one plane. The only limitations on shape are those imposed by manufacturing conditions and the requirements of the user.



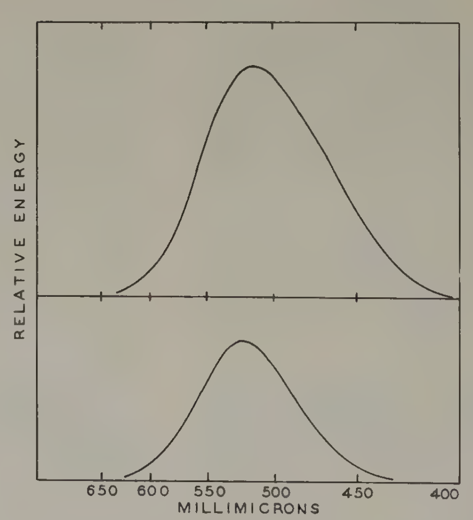


Fig. 1 (left). Relative spectral energy distribution of light output of 60-cycle lamps. *A. Blue phosphor; B. Green phosphor; C. Yellow phosphor—low manganese; D. Yellow phosphor—high manganese.* **Fig. 2 (above). Effect of frequency on relative spectral energy distribution of light output of lamps made with green phosphor. (Top) 500-cycle, (bottom) 60-cycle operation**

OPTICAL CHARACTERISTICS

THE color of the light emitted by the lamp is determined by the phosphors used in its manufacture. These phosphors have been described by Homer, Rulon, and Butler.[4] They are zinc sulfides, activated by combinations of lead, copper, chlo-

A special article recommended for publication by the AIEE Committee on Production and Application of Light.

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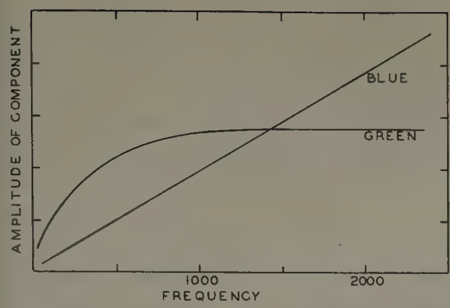
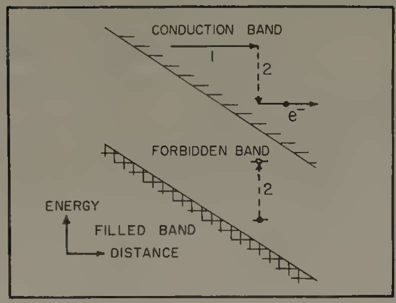




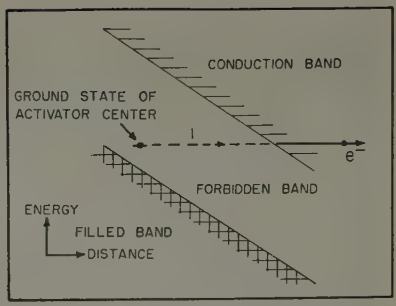


Fig. 3 (left). Relative magnitude of green and blue component bands in the spectral energy distribution of light emitted by lamps made with green phosphor. Fig. 4 (center). Excitation by collision: 1. Electron in conduction band gains kinetic energy from electric field. 2. Electron makes inelastic collision with activator center, leaving it in excited state. Fig. 5 (right). Direct excitation: Electron in ground state of activator penetrates forbidden band by wave mechanical "tunneling." Upon reaching conduction band, it is removed by the electric field, leaving activator center ionized

ride, and manganese, and can be made in a range of colors from a deep blue through green to yellow and orange. By using a mixture, composed mainly of blue and yellow phosphors, white light of any desired color temperature between 2,500 K and 25,000 K also may be produced.

The common characteristic of all of these phosphors is the use of relatively large amounts of the copper activator in combination with trace amounts of the lead sensitizer. This basic combination gives a phosphor whose emitted light is composed of two major broad component bands, one in the blue centered at 460 millimicrons and a second in the green centered at 520 millimicrons. The relative intensity of these components can be controlled[4] by varying the copper and chloride activator concentrations over a limited range, thus allowing a continuous variation, if desired, from deep blue through blue-green to a yellow-green. However, from the manufacturing standpoint, it is preferable to produce only the deep blue and the pure green phosphor and to obtain intermediate colors by the use of mixtures.

It has been shown by Waymouth[5] that the frequency dependence of the two component colors of the light from copper-activated zinc sulfide is quite different. The blue component increases linearly with the frequency of the alternating current, up to the highest frequency employed, while the green component reaches saturation at about 1,000 cycles. This phenomenon is attributed to the time required to "activate" the two types of centers, i.e., the time required to activate the blue centers is less than the shortest period encountered (5×10^{-4} second), while the saturation of the green band at 1,000 cycles indicates an activation time comparable to 10^{-3} second. This difference explains not only the color shift but also the saturation effect discussed later.

If the formulation of the zinc sulfide phosphor is modified to include manganese as well as copper, lead, and chloride, the two emission bands due to copper are gradually suppressed as the manganese content increases while a new emission band centered at 590 millimicrons appears. Thus it is possible to get a continuous shift from green through yellow to a deep orange.

The spectral energy distribution of typical blue, green, and yellow phosphors with the abscissa giving the wavelength of emitted light is shown in Fig. 1. These determinations were made at 60 cycles.

Fig. 2 shows the effect of frequency on the emitted light from a green phosphor. It also shows the increased importance of the blue component at 500 cycles by its effect of making the distribution more asymmetrical.

The magnitude of the component bands as affected by frequency is shown in Fig. 3. The ratio of the amplitudes of the green and blue bands is about 10/1 at 60 cycles while at 2,000 cycles the ratio becomes 0.7/1, so the color shift is from green to a somewhat greenish blue as the frequency increases.

MECHANISM OF ELECTROLUMINESCENCE

COMPARISON of the light emitted by the phosphors with various methods of excitation shows that electroluminescence and other forms of fluorescence differ chiefly in the way in which energy is supplied to the activator centers and the mechanism of electroluminescence must involve some direct means of transfer of energy from the electric field to the activator centers. This can be accomplished only through the motion of charged particles, such as electrons.

At present, the most plausible mechanisms for this transfer are

1. *Excitation by Collision.* According to this explanation, electrons from donor centers are freed either thermally or by the electric field, and enter the conduction band, in which they are accelerated by the electric field until they have kinetic energies sufficient to excite or ionize activator centers. This process, which has been proposed by Curie,[6] Burns,[7] and others,* is illustrated schematically in Fig. 4.

2. *Direct Field Ionization.* This mechanism requires that in a strong electric field electrons in bound states of activator centers may escape to the conduction band by the well-known wave mechanical tunnelling process, as shown in Fig. 5. This process has been suggested independently* by Burns,[7] and by Bitter and Vasileff in letters to the authors.

While various objections can be raised to the postulated mechanisms, the most valid of these is that it has been

* Piper and Williams[8] and Lehovec, Accardo, and Jamgochian[9] have discussed the electroluminescence obtained with large single crystals, using electrodes in contact with the crystal and have suggested similar mechanisms for this type of luminescence. The mechanism of energy transfer for the direct contact may be entirely different, however, from that applying when the phosphor crystals are isolated from the electrodes by the suspending dielectric.

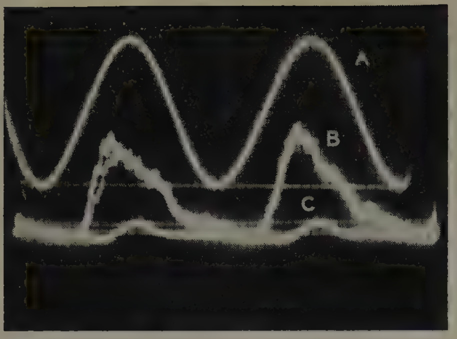


Fig. 6. Montage of traces of light output from "spot," voltage, and dark current
A—Voltage applied to electrodes
B—Light output from spot
C—Photomultiplier dark current. (Note that the zero of light is arbitrary, since a d-c amplifier was not used; therefore a nonvarying component of light output could not be detected. Dark current and light output traces are superimposed as if there were no nonvarying component of light output)

necessary to assume very large rate constants in the theory to account quantitatively for the observed luminescence, especially at low average electric field strengths (50 to 150 volts per mil). However, it has been shown recently that the electroluminescence of individual insulated particles of these phosphors with excitation by alternating electric fields is by no means uniform, but is confined almost entirely to very tiny bright "spots," especially at average electric field strengths less than 125 volts per mil. In striking contrast, the luminescence of the same particles under ultraviolet excitation is uniform. Two types of spots have been observed. The first of these is located at the junction between two apparently similar crystallites of an agglomerate, while the second is located at the tip of a needle-shaped crystallite. The "junction" type of spot luminesces most strongly when the electric field vector is at right angles to the plane of the junction, while the "tip" spot luminesces most brightly when the electric field vector is parallel to the axis of the needle-shaped crystallite. When the direction of the electric field is varied, the luminescence falls off rapidly with deviation from the preferred orientation.

These observations strongly suggest that the reason for electroluminescence in "spots" is the concentration of the electric field in the region of the spot by the electrical inhomogeneity of the particle. If it is assumed that all of the potential difference across a particle may be concentrated across one spot, it can be calculated from the spot size (about 1–2 microns) and the crystallite size (10–20 microns), that the electric fields within the spots easily may reach ten times the average electric field within the lamp. It is conceivable, therefore, that electric fields of 10^6 volts per cm and more may exist within these electroluminescent spots.

At such fields, both of the mechanisms which have been proposed seem entirely plausible, though unfortunately, it is difficult to distinguish between them. It is instructive, however, to inquire somewhat more deeply into the mechanism whereby the electric field might be concentrated at a junction between two crystallites. One attractive possibility is to assume that the junction is actually a *P-N* junction; such a junction would be a rectifier, and therefore would have a high field within the region of the junction when the applied field was in the "reverse" direction (*N*-side positive).

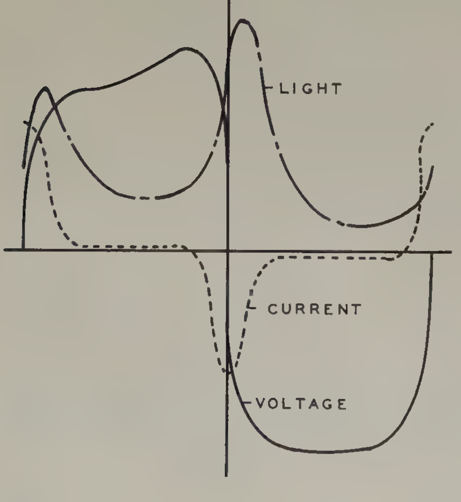
It has proved possible to photometer the light radiated from a single spot. When such photometry is performed on junction spots, only one major light peak is observed each cycle. Fig. 6 shows typical results: Trace *A* is the voltage applied across the electrodes; trace *B* is the light emitted from the spot; trace *C* is the dark current.† Two complete cycles are shown; note that there is only one major light peak each cycle, and that this peak is located about 50° after a voltage zero. Thus these observations tend to confirm the rectifying junction hypothesis of "spot" formation.

When observing single junctions, it is found that there is a threshold of electric field below which no light can be measured and that above this threshold, the light output shows a linear increase with applied field.

ELECTRICAL PROPERTIES OF LAMPS

THE discussion of the mechanism of luminescence has dealt with the behavior of individual particles of phosphor. Any practical electroluminescent lamp, no matter how small, is composed of a vast number of such individual particles, no two of which may be exactly alike. Therefore,

† In constructing the photomontage of Fig. 6, it was assumed that the light decays to zero each cycle. This could not be checked experimentally, since a d-c amplifier was not used.



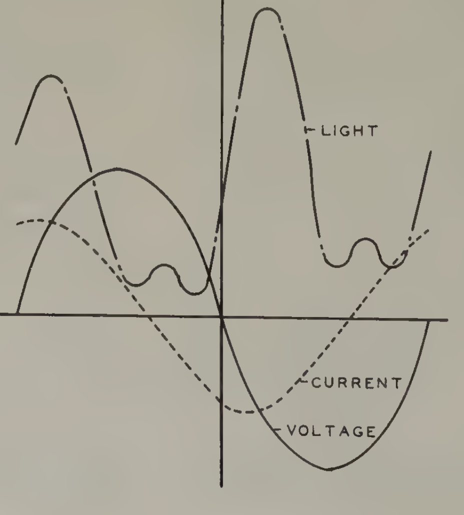


Fig. 7 (left). Oscilloscope traces of light, current, and voltage for an electroluminescent lamp with approximately a square-wave applied voltage. Fig. 8 (right). Oscilloscope traces of light current and voltage for an electroluminescent lamp with a 60-cycle sine wave of applied voltage

results obtained from measurements of these lamps indicate the over-all average of the behavior of individual particles.

Oscilloscope traces of light and current resulting when a square wave voltage is impressed across an electroluminescent lamp are shown in Fig. 7. It will be noticed that flashes of light are obtained only when the voltage reverses polarity.

When a sinusoidal voltage is applied to the lamp, the voltage, current, and light relationships are as shown in Fig. 8. Here again, the typical leading current of a capacitor is found. It will be noticed that the light output repeats itself at twice the frequency of the applied voltage. This behavior of the light output has been attributed to the absorption and release of power by the lamp. In the traces it can be seen that the flashes of light are obtained when the current and voltage are in phase, i.e., power is being absorbed by the lamp. Due to the random orientation of the individual particles two light pulses are obtained, one for each direction of the electric field.

With a varying sinusoidal voltage applied to the lamp, the light output is found to vary with the voltage‡ as shown for one type of lamp in Fig. 9. This figure should not be construed necessarily as indicating a threshold voltage for light output of the order shown. Measurable light output on this lamp has been obtained down to very low voltages by increasing the sensitivity of the meter. However, on the scale of this figure, the values below 100 volts are insignificant.

The rapid variation of light output at low voltage may seem to disagree with the linear relationship found on single particles. However, if it is recognized that the particles have a random orientation and that the voltage threshold for luminescence depends sharply on this orientation, this disagreement vanishes, since a rapid increase in the number of particles capable of luminescence occurs as the voltage is increased.

Fig. 9 could be made more fundamental if electric field strength were used instead of the applied voltage. Theoretically, the voltage scale could be changed at will without changing the light output scale merely by changing the thickness of the dielectric layer. However, this ideal is impossible to attain in practice at the present state of the art because of the factor of safety which must be built into

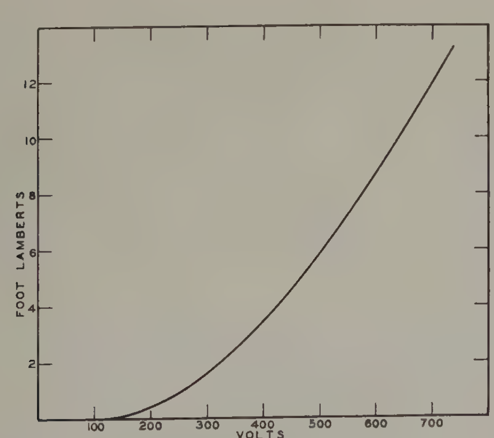
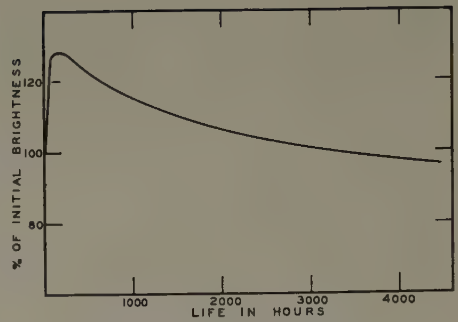


Fig. 9. Measured brightness of a green electroluminescent lamp with varying 60-cycle voltage.

Fig. 10. Maintenance of brightness of a typical electroluminescent lamp operated on 600-volt 60-cycle current



the lamps to provide for surges in the line voltage and for variations in thickness over the area of the dielectric layer. Since this safety factor of added film thickness is roughly independent of the film thickness, it constitutes a higher percentage of the total for thin films than for thicker ones. Consequently, lamps for high-voltage operation are, in general, brighter than those for low-voltage operation.

The magnitude of attainable brightness with these lamps is dependent on the phosphor and the resistivity and dielectric constant of the dielectric material in which it is imbedded. However, the materials which can be used for lamps for most applications are restricted to those forming solid and continuous films of high stability, even though these may not give maximum brightness. Lamps currently being produced for operation at 600 volts, 60 cycles, have brightnesses of the order of 10 foot-lamberts. This brightness can be increased manyfold by operation at higher frequencies as will be discussed shortly.

The maintenance of lamp brightness with time is an item of prime importance to users. The maintenance curve of a typical production Panelescent lamp is shown in Fig. 10. It is quite noticeable that there is a rapid increase in brightness in the first few hours of operation. This is then followed by a slow depreciation which is approximately exponential.

A most important property of any light source is its expected life. The major causes of failure of these lamps are puncture of the dielectric at a thin spot, if a high-voltage surge is applied, and decay of the light output below a minimum acceptable level.

Since a puncture due to surges in line voltage tends to be self-healing, leaving only a small black "speck," it is very seldom the cause of failure. This leaves the decay of light output below acceptable levels as the primary cause for replacement of these lamps. Since the rate of decay can be very gradual, it is obvious that the electroluminescent lamp is a potentially long-lived source of light.

The lumen output as a function of power consumed for a lamp is shown in Fig. 11. This is a 600-volt lamp of 35-square-inch area. The efficiency increases with increasing voltage up to 500 volts beyond which the efficiency decreases. At 500 volts the efficiency was 4.24 lumens per watt.

A considerable increase in brightness of these lamps can be attained by operation at higher frequencies than the usual 60 cycles per second (cps). This is shown in Fig. 12

‡ This variation may be approximated by either an exponential or a power function of voltage. It is higher than quadratic at low voltage and becomes nearly linear at high voltage.

wherein one of these lamps increases in brightness by a factor of 20 when the frequency is changed from 60 to 4,000 cps.

The use of high frequency for operation of electroluminescent lamps is subject to a limitation which is inherently due to the high resistance of the conducting glass.§ As the frequency increases, there is a linear increase in current and a square law increase in the heat generated in the glass. This heating cuts down the light output and shortens the useful life of the lamp because of poorer maintenance.

APPLICATIONS OF ELECTROLUMINESCENT LAMPS

It is obviously impractical to list all the possible specific uses for electroluminescent lamps. However, the applications of the present types of lamps can be classified broadly into three groups:

1. 120-volt 60-cycle lamps give light intensities of the order of 0.1 foot-lambert. They are suited for uses where the ambient light level is low.
2. 600-volt 60-cycle lamps can give light intensities up to 10 foot-lamberts and are suited to applications, such as signs, in areas where the ambient light is moderate.
3. 600-volt lamps designed for use at higher frequencies are suitable for uses where ambient light levels are high.

A specific application, for which a light intensity of 0.1 foot-lambert is entirely adequate, is that of clocks, where the uniformly lighted dial not only makes it easy to tell the time, but also acts as an excellent light source for the dark adapted eye. Another similar use is the lighting of radio dials where the low light intensity obtained at 120 volts is frequently sufficient, though it can be increased readily by using higher voltages. In these and other applications, the fact that the electroluminescent lamp, because of its construction, can cause no radio interference may be advantageous.

The obvious advantages of long life, good maintenance, and uniform illumination will make the electroluminescent lamp a useful light source for crowded instrument panels, such as those of aircraft. In this application the ability to control light intensity without change of color or loss of uniformity also may be important.

§ Normally this is about 500 ohms per square.

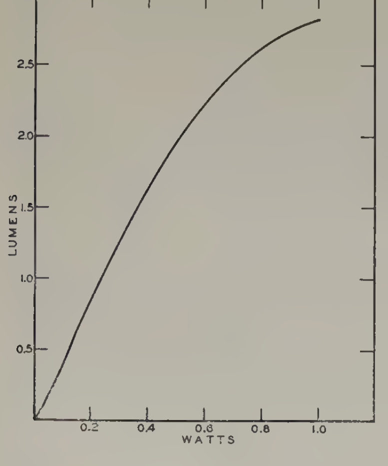


Fig. 11. Relationship between power consumption and light output for a typical green electroluminescent lamp.

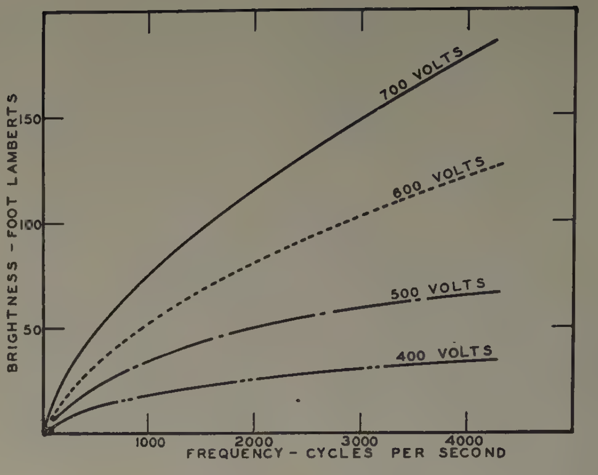


Fig. 12. Measured brightness of a green electroluminescent lamp at varying voltage and frequency

At the higher intensities, obtainable with either 600-volt 60-cycle current or with higher frequencies, the unique thinness of the lamp and the wide range of shapes and colors available give designers a wide latitude. Once again instruments can benefit since central station boards well could use instrument dials lighted by electroluminescent panels. The awkward design problems found with incandescent dial lighting and the need for frequent replacement would be avoided.

It is easy to think of a wide variety of signs which could be made with electroluminescent lamps. Street signs, house numbers, theater exit signs, as well as colorful displays suggest themselves immediately. By providing battery-operated vibrators such signs could be powered for emergency use if desired.

CONCLUSION

An attempt has been made to outline some of the characteristics of the electroluminescent lamp, to explain why it works, and to point out some of the possible uses. This new light source has unique features which should lead to rapidly increasing application as it becomes more readily available.

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Analyzing Rotating Machinery by Network Theory—II

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WHEN NETWORK THEORY is used, the analysis of the commutating machine differs from that of the noncommutating machine in that a new transient is initiated as the commutator segments enter or leave the brush contact area. In establishing the equations of operation, each interval of time during which no switching occurs is considered. As in the analysis of the noncommutating machine, the first step is that of establishing a connection diagram of the machine for the interval of time under consideration. When the general condition of q_1 and q_2 coils in each commutating zone is considered, the connection diagram is applicable to all intervals. The inductances are determined as a function of time from a second diagram showing the physical orientation of the elements as a function of rotor position.

Following standard network theory, the mesh-circuit differential equations are written from inspection of the connection diagram or where the diagram is unusually complex, the mesh-circuit equations are obtained from the branch circuit equations by means of a matrix transformation of variable. The mesh-circuit equations thus obtained have variable coefficients and are too complex to be of practical value in engineering studies. Because of higher harmonics present in the air-gap field of commutating machines, it is very difficult to find a transformation of variable that will remove the variable coefficients as is done in the analysis of noncommutating machines where harmonics above the second are neglected. However, since the equations only apply for small rotor displacements, the coefficients can be considered constant over the relatively short intervals of time without introducing any excessive errors.

In the analysis of commutating machines, two distinct aspects of the problem are of interest. (1) Assuming the machine commutates satisfactorily, what are the external transient and the steady-state characteristics of the machine when used as a component of an electric system and subjected to a given set of operating conditions? (2) Knowing the external characteristics and conditions of operation, what are the conditions in the commutating zone that must be met to insure satisfactory commutation? From this point of view, one is not particularly interested in analyzing the machine under conditions of poor commutation where it is impossible to evaluate the contact resistances. Each of the aspects of the problem are efficiently studied when the equations are written in matrix form and the matrices partitioned in such a manner as to separate the equations of the commutating coils from those of the field and armature branch circuits. It can be shown that the total effect of all the currents in the coils undergoing commutation on the field and armature branch circuits is negligible as linear commutation is approached. Therefore, the armature branch circuit and field circuit equations can be solved independently of the commutating coil circuit equations to obtain the external characteristics. If the usual machine symmetry is assumed and if it is further assumed that there are the same number of coils in the commutating zone during each interval, then the connection diagrams for all intervals are identical and the armature current just before switching, $(t=0-)$, will be equal to that just after switching, $(t=0+)$. Therefore, the solution to the circuit for the first interval of time applies equally well for each of the successive intervals. Thus, the external characteristics are obtained by solving the network for the interval of time during which no switching occurs. The solution then is shown to apply for successive intervals if certain assumptions about the network are made.

In studying the commutation characteristics, the external current characteristics are substituted into the original differential equations of the machine as known functions. The number of equations describing the commutating characteristics is equal to the number of coils in the commutating zone. Since the self- and mutual-inductance coefficients in the equations are all of the same order of magnitude, much improvement in accuracy results when a transformation of variable is applied to the current and voltages to produce a new set of equations, the coefficients of which are the differences between the self- and mutual inductances of the original equations. Again, this type of transformation is clearly and efficiently applied when matrix algebra is used and the resulting coefficients are clearly defined in terms of the original. If desirable, the new or transformed coefficients (differences between the self- and mutual inductances usually referred to as leakage inductances) can be evaluated directly from machine dimensions. When applied to a 2-winding transformer, this type of transformation leads immediately to the T-equivalent circuit of the transformer.

After processing the differential equations of the machine in the foregoing manner, the equations have practical value in engineering studies, where by the use of computing equipment the solutions to the equations of commutation can be studied under both transient and steady-state conditions. The effects of the eddy currents in the solid frame are approximated by an equivalent winding closed on itself. Since the equivalent inductance of the eddy-current winding is a function of frequency, it may be desirable or necessary to study the transient commutating characteristics in terms of the various frequency-response characteristics.

Digest of paper 54-88, "Application of Network Theory of the Analysis of Rotating Machinery. Part II—Commutating Machines," recommended by the AIEE Committees on Basic Sciences and Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Communication and Electronics*, May 1954, pp. 169–77.

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Fundamental Oscillations of Coils and Windings

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THE NORMAL FUNCTIONS of a coil or winding are obtained from the solution of the Fredholm integral equation

$$U(x)=\lambda LC_g\int_0^1 K(x, s)U(s)ds \tag{1}$$

In the foregoing equation $U(x) = U(s)$ is the unknown voltage distribution along the winding, L is the self-inductance of the winding and C_g is the total capacitance to ground, assumed to be uniformly distributed, $K(x, s)$ is the kernel of the integral equation which is a function only of the self-inductance function $L_o(x, s)$. Finally the parameter λ, is simply the square of the angular frequency.

$$\lambda=\omega^2=4\pi^2f^2 \tag{2}$$

Since the unknown voltage distribution $U(x)$ and $U(s)$ appears both outside and under the integral sign, and the integration limits are fixed, this is a homogeneous integral equation, of the type studied by Fredholm 50 years ago.

The values of λ are called eigenvalues, or normal values, or characteristic numbers of the homogeneous integral equation. To each corresponding pair of possible values of λ_n and f_n there is associated a voltage distribution $U_n(x)$ which corresponds to the nth harmonic.

The fundamental frequency with isolated neutral $f_i\sqrt{LC_g}$ and the fundamental frequency with grounded neutral $f_g\sqrt{LC_g}$ as well as their ratio f_g/f_i are plotted in Fig. 1, as a function of the ratio

$$\frac{L_o\,(1/2)}{L_o\,(1)}=\frac{\text{self-inductance of half the coil}}{\text{self-inductance of the entire coil}} \tag{3}$$

which is very easy to measure.

For a transmission line the fundamental frequency with isolated neutral takes the limiting value

$$f_i=1/4\frac{1}{\sqrt{LC_g}}=\frac{0.250}{\sqrt{LC_g}} \tag{4}$$

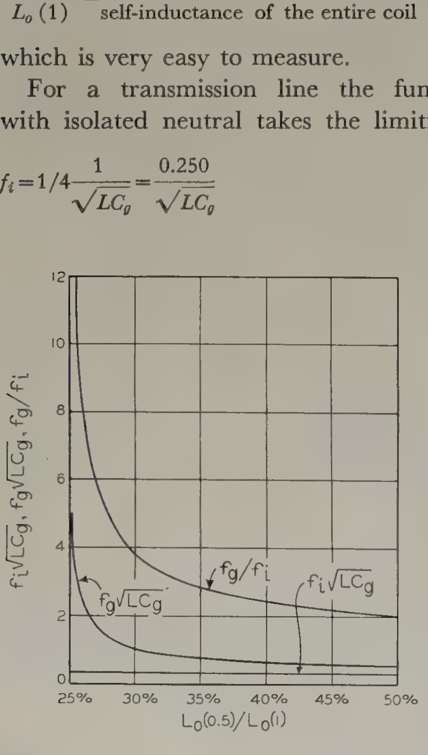

Fig. 1. Fundamental frequencies of air and iron-core coils with grounded neutral (f_g) and isolated neutral (f_i). $L_o(1)$ is self-inductance of the coil, $L_o(0.5)$ is self-inductance of half the coil

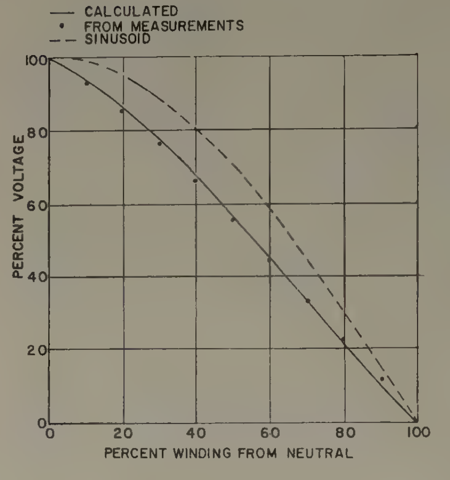

Fig. 2. Fundamental voltage distribution in uniform iron-core coil with isolated neutral

The other limit is

$$f_i=\frac{\sqrt{3}}{2\pi}\ \frac{1}{\sqrt{LC_g}}=\frac{0.276}{\sqrt{LC_g}} \tag{5}$$

for the ideal transformer which has constant mutual inductance between turns and no leakage flux. It is really astonishing that such a radical change in the shape of the mutual and self-inductance functions produces only a 10.3-per-cent difference in f_i.

A winding with both ends grounded, however, behaves quite differently from a transmission line. In fact the frequency ratio f_g/f_i may vary between 2 (transmission line) and infinity (ideal transformer). This ratio depends only upon the shape of the mutual inductance function.

Iterative solution of the integral equation shows that the waveshapes of the fundamental oscillations of actual air coils, iron-core coils, and transformer windings are *not* sinusoidal, or cosinusoidal as heretofore assumed in the literature. This is proved by the good agreement between computed and measured values for an air coil, an iron-core coil, and a transformer winding (Fig. 2). When the neutral is isolated, the waveshape of the fundamental is almost a straight line for transformer windings with an iron core of high permeability, and the distribution deviates more and more from the straight line as mutual inductance is decreased, until a cosine function is obtained for transmission lines, which have no mutual inductance. When the neutral is grounded the waveshape is practically a sine wave for transformer windings and becomes more peaked as the mutual inductance is decreased.

Digest of paper 54-13, "Fundamental Oscillations of Coils and Windings," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, February 1954, pp. 1–10.

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This article is based in part on a thesis submitted by P. A. Abetti in partial fulfillment of the requirements for the degree of doctor of philosophy in electrical engineering at Illinois Institute of Technology.

Current-Carrying Capacity of Pipe-Cable Systems

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EXISTING METHODS for determining current-carrying capacity of pipe-cable systems under cyclic loading[1–5] have certain limitations. Generally these methods are set up to handle the steady-state case of single-pipe systems only, although one method[5] has been extended to the multipipe case and presumably the other methods could be so extended.

During system contingencies cable loading may change from normal to emergency levels for periods from a few hours to hundreds of hours. On 2-pipe systems the contingency may affect both pipes or only one pipe. In the latter case the second pipe may continue at normal loading or may be de-energized and cooling off.

A new method has been developed which treats all of these transient problems as well as steady-state problems on single-pipe and multipipe systems.

The new method is based on a modification of "equation *2*" mentioned in references 1–4. In the equation *2* method the total thermal circuit of a pipe-cable system is divided into internal and external components, H_{int} and H_{ext}, the line of division being at the pipe surface, and the loss factor is applied to H_{ext} only.

The use of equation *2* for cyclic loading, in effect, evaluates a mean pipe temperature as shown by smooth curve *B* in Fig. 1. The actual pipe rise is shown by saw-tooth curve *A*. After a few cycles of loading the difference between *A* and *B* becomes practically constant and an easily determined factor, *C*, can be developed to correct for this difference.

In addition an internal attainment factor, AF_{int} is applied to H_{int}. These two factors are used for the steady-state and transient cases. Another attainment factor, AF_{ext} is applied to H_{ext} for transient cases only.

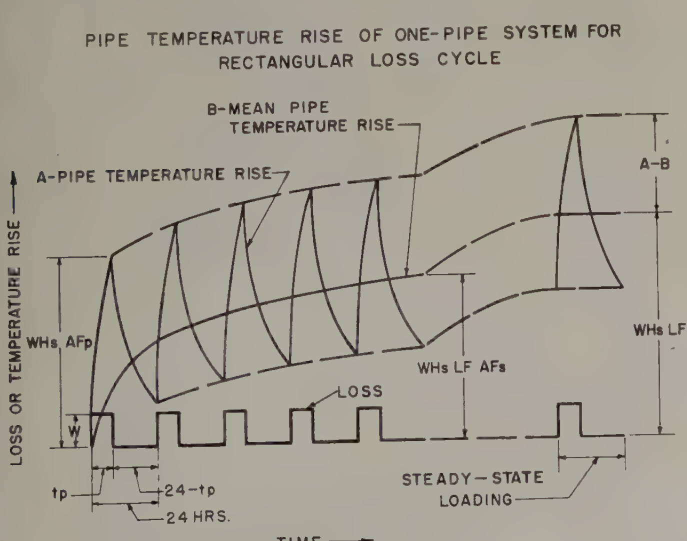

Fig. 1. Pipe temperature rise of single-pipe system for rectangular loss cycle

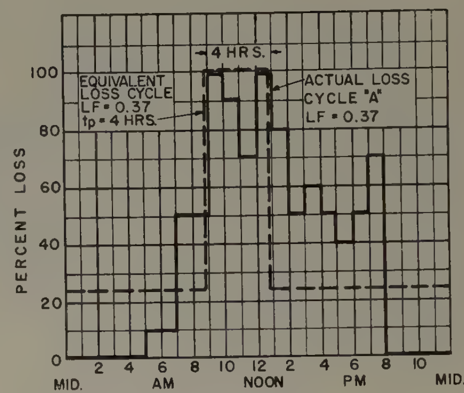

Fig. 2. Actual and equivalent loss cycle. Commercial cycle "A," shown in Table II, reference 1

The proposed method is developed specifically for standardized loss cycles consisting of a rectangular block superposed on a constant base. Most commercial cycles can be represented in terms of such an equivalent cycle, if the loss factor of the equivalent cycle is equal to the loss factor of the actual cycle, and the duration of the peak load period, t_p, of the equivalent cycle reasonably approximates the peak load period of the actual cycle. An example of an actual and equivalent cycle is shown in Fig. 2. Calculations made for several different pipe-cable systems using the proposed method with an equivalent cycle gave results in very good agreement with results obtained by Neher[2] using the analogue computer with the actual loss cycle.

Tables of AF_{int} and curves of AF_{ext} simplify the application of the method. Working equations may be obtained for steady-state and various transient cases on single-pipe and 2-pipe systems. The proposed method treats the internal and external components separately in accordance with their different thermal characteristics, is extremely flexible and only slightly more difficult to use than equation *2* or other steady-state methods, gives correct conductor and pipe temperatures, and while set up specifically for standardized block load cycles may be modified easily for other cycles.

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Performance Specifications Are Needed for Electronic Control

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The establishment of performance specifications are a necessity not only to specify anticipated performance but also to establish the limits of responsibility between the user of the device and its manufacturer. Included in performance specifications are a device's operational characteristics, its limitations, and its rating.

THE PROGRESS of industrial electronic control is being seriously hampered—hampered by misunderstanding, misapplication, and mistakes—hampered by a failure to grow up and assume its rightful place in industry. When electronics first stepped into the picture it was hailed as the all-conquering hero. Mistakes were forgiven, because a beginner always makes mistakes, but now it is time electronic control came of age and started establishing standards of performance; standards of reliability; standards which measure up to industry's high level of acceptance.

This article deals with the first step: establishing the need for performance specifications. Performance specifications are needed to specify anticipated performance, but equally important, they are needed to establish limits of responsibility between the users and the manufacturer. How many times have you built something for someone only to find your efforts had been misdirected? Good performance specifications can help prevent this.

If you are a user of electronic control, you need performance specifications in order to know if you are getting the right apparatus to perform the function you require. You need them to know what your responsibilities are; and what the manufacturer's responsibilities are. You need them to know what conditions of operation you must provide to get the most out of the equipment. In short, you need them to be sure the apparatus is worth the money spent and to tell you how the apparatus may be used most effectively.

If you are a manufacturer, performance specifications tell you what you must build into the control to make it satisfactory. They help you convey to the user what the control will do and assist him in determining whether *this* will be a satisfactory application for this particular device. They define the conditions the user must provide for satisfactory operation and, to repeat, they serve to determine the limits of responsibility between these two parties concerned, the user and the manufacturer.

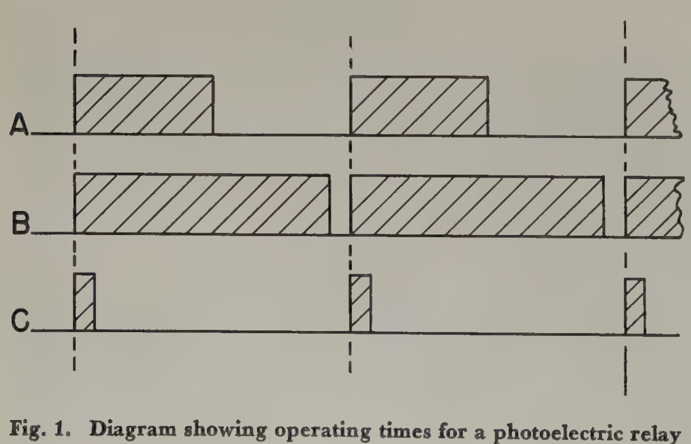

Fig. 1. Diagram showing operating times for a photoelectric relay

Now what do performance specifications include? One definition could be: performance specifications are statements of the operational characteristic, limits, and ratings of a device or system. They should include:

1. The functions for which the device or system is designed.
2. The rating of the device or system expressed in terms of voltage, current, speed, regulation, or whatever the function might be.
3. The limits or conditions under which these functions and ratings can be performed successfully and the tolerance of performance.
4. Additional application data which will aid in the use or application of the device or system.

DEFINITION OF TERMS NEEDED

THE FIRST STEP in establishing performance specifications is to develop a common language of terms which all understand. Unfortunately, a very good job has not been done in the field of industrial electronic control. Certainly it can not ask to be excused on the basis that it is one of the newest members of the industrial control family. Uniformity of specifications and standards have not been established as they have for general purpose control in the areas of contactor ratings, breaker ratings, fusing, short-circuit protection, etc. Only in one area of industrial electronics has progress been made and that has been in the resistance welding industry. Here types of controls, functions, ratings, and limits of performance have been discussed, specified, and ultimately standards established. A given resistance-welding-control type automatically tells the purchaser what he may expect in the way of functions and performance, while it also tells the manufacturer what he must provide. It is recognized that this same degree of

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success may not be achieved in other areas of industrial electronic control because of the varying complexities and special purpose functions which are provided only infrequently, but nevertheless, there is much work that can and should be done.

Industrial control falls into two principal groups. One is known as open-cycle control devices or systems, of which the electronic timer, the photoelectric relay, or a resistance-welding control are examples, and the other is known as a closed-loop system, of which the position regulator and the voltage regulator are examples. Although the control complexity may be greater in the case of closed-loop control systems, the need for specifications is important equally in each area and in each area there are many examples of confusion, poor terminology, and misunderstanding.

OPEN-CYCLE CONTROLS

For a simple example, consider the electronic timer. Among some of the various items which could be specified are

1. Time range.
2. Timing accuracy.
3. Contract rating.
4. Voltage and temperature effects.
5. Reset time.
6. Type of operation.

There are many more, but these are enough to make the point. None of these represents information which is difficult to determine but there must be a meeting of the mind on what these terms mean. For example, take a specification on timing accuracy. This can be interpreted as repetitive accuracy, which means the accuracy with which this timer will repeat a given timed interval. Or it may mean calibration accuracy which could mean full-scale accuracy or it might mean how well the time intervals match the calibrated dial settings at a partial time setting. Each of these also could be expressed in terms of a short-time accuracy which would neglect tube drifts or component changes, or they may be expressed in terms of a long-time accuracy which would include such drifts. Obviously they are different. Accuracy also is definitely tied up with variations in line voltage. It can be defined under the conditions of constant voltage or with a voltage variation. Again, voltage variations may be a result of gradual drifts, such as occur periodically during the day, or they may be due to transient changes or regulation such as result from instantaneous load changes. At any rate, if timing accuracy is to be defined in terms that mean something to both the user and the manufacturer, a common language is needed as a basis of discussion.

Another example is in the case of the photoelectric relay. Among the specifications are

1. Operating distance.
2. Per cent of light change for operation.
3. Contact ratings.
4. Number of operations per minute.
5. Response time.
6. The effects of voltage and temperature.

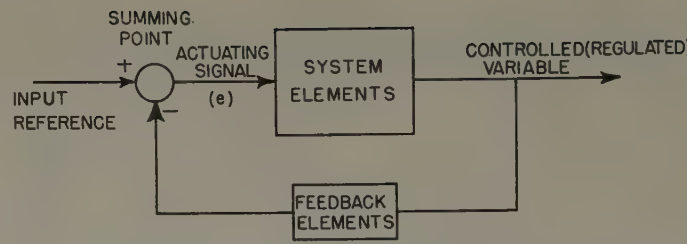

Fig. 2. Simplified block diagram of a simple feedback-control system

From these, consider the number of operations per minute which is a commonly used term. Assume that the user has a situation where he may want to count up to 100 packages per minute on a conveyor and he chooses a relay which the manufacturer indicates will operate up to 150 operations per minute. He should be on safe ground but he may or may not have trouble, depending on how the number of operations per minute was determined. Actually the number of operations that this relay will perform satisfactorily depends on the response time of the relay, its pickup time, and its drop-out time. Fig. 1 illustrates this point. For this example, assume the relay drops out during the shaded area and picks up the remainder of the time. In case *A*, the package is of sufficient size that the photoelectric relay is energized for half of the time and would have little difficulty in picking up and dropping out properly. On the other hand, in case *B*, suppose the packages are very long so that the time during which the relay is energized is very short. If the response time of the relay is not fast enough, it will not operate satisfactorily regardless of whether the number of counts per minute are 100 or 150. In case *C*, where the object to be counted is small, a short drop-out time of the relay is necessary in order to give an accurate record of the number of units per minute. Here is not a difficult problem, but merely a need for common basic terms and an understanding both by the user and the manufacturer of what performance specifications should be given.

CLOSED-LOOP CONTROL

Now consider an example from the closed-loop type of control. To digress a moment, with the constant and marked progress of industry in the direction of improved production, quality, cost reduction, and in the introduction of new and automatic methods and processes, closed-loop control has become a key factor. Here, the need for common terms, definitions, and standard of performance is of increasing importance. Closed-loop control is required so often because it is a system which measures performance against a standard or reference and constantly maintains performance within certain predescribed limits. It gives the user the advantage of a more precise automatic control system. By a simple block diagram, Fig. 2, a closed-loop control system may be indicated. Here a reference and a feedback voltage are compared at the summing point and the difference or actuating signal is used to control the system elements, which in turn control the regulated variable. This is a closed-loop control system in its simplest form.

Now for an actual example, take a single-dimension

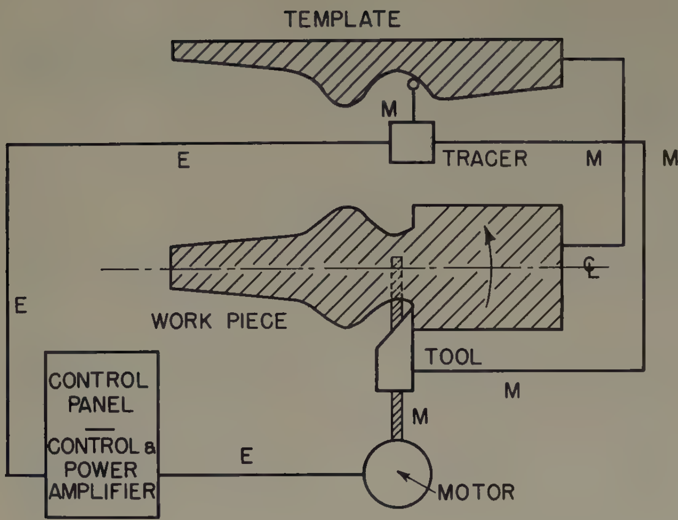

Fig. 3. Diagram of a single-dimension contouring control system in which the connections indicated by *E* are electric and those marked *M* are mechanical

contouring control system for a lathe. Here the object is to guide the lathe automatically so that it will reproduce a given part in accordance with a template or pattern. Fig. 3 shows this system. To enumerate the system elements, the first is a template, which is the reference. A tracer head with a stylus feels the template, and by the deflections of the stylus it gives actuating signals to the control and power amplifier, which in turn drives the motor. The motor is directly connected to the lead screw which repositions the stylus of the tracer, keeping its signal commands within limits determined by several factors, among them the system sensitivity and frequency response. Since the tool and the tracer are tied together mechanically, the tool also is repositioned automatically as the tracer is moved with respect to the template. In this way, the template outline is reproduced automatically by the cutting tool.

Notice that each of the ties between the elements is marked *E* or *M*, indicating whether the tie is electric or mechanical. The tie between the tracer head and the stylus is mechanical and is determined by the stylus length and the material used. The ties between the tracer head, the control, and power amplifier are all electrical. The ties between the motor, tracer head, and the tool are mechanical as are the ties between the template and the machine.

Now if there were no mechanical inertia, no backlash in the feed drive, no windup or torsional deflection in the lead screw, no stickiness or variable friction in the machine ways, no induced vibrations, deflection, or misalignment of machine members, the problem would be a simple one. However, this is not so and all these factors affect greatly the operation of the system. Therefore, they bear equal importance with such control parameters as frequency response, sensitivity, velocity-error coefficient, cutoff frequency, etc. All too often, the machinery manufacturer wants a performance specification which says without qualification that the system has a certain accuracy and speed of travel. Furthermore, he feels that by specifying a certain velocity-error coefficient and a certain cutoff frequency, the remaining items are insignificant. That is not so. While it is agreed fully that specification of the control must be clearly defined, so must the limits of responsibility. Likewise, the machinery manufacturer must be aware of his responsibility to build satisfactory servo-characteristics into the machine if greater success is to be achieved. Here the true importance of specifications can be realized in the sense that they determine the limit of responsibility for the control manufacturer and the machinery manufacturer regarding the successful performance of this system.

TYPES OF TROUBLES

Now consider for a moment the types of troubles these mechanical deficiencies produce. Backlash in the lead screw acts much as a dead zone or blind spot during which the control must search for the correct position. It may be likened somewhat to driving an automobile with excessive play in the steering apparatus. In this case, the automobile may wander slightly as it goes down the road in spite of the driver's best efforts to follow a straight line. Regardless of the accuracy of the tracer head and the control system, backlash will be one of the most important mechanical considerations which will limit performance of this type of system.

Windup or torsional deflection of the lead screw can be translated directly in terms of an error in deflection of the tracer head. On large machines it may be an important factor.

Stickiness or misalignment of the machine ways means that the control may have to exert extra forces in order to break the machine away from a stationary position. While certain control functions may be introduced to minimize this shortcoming, nevertheless, its elimination automatically would mean better performance. Vibration may cause deflections of the stylus which might be equal to the degree of accuracy sought. These vibrations may be generated by gears or other mechanical machine faults. Likewise, deflection of machine members is of utmost importance. For example, if the template is not mounted securely on the machine, any deflection of it will represent an undesired change in the position of the reference and, consequently, an error equal to the deflection of the reference. Likewise, deflection in the tool or any other machine parts will cause a variation between the template and the reproduced part. All of these various mechanical faults may be minimized by proper design of control systems, but this effect cannot be

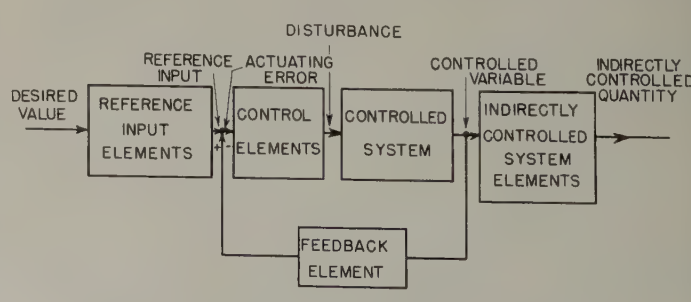

Fig. 4. Block diagram of a feedback control system

eliminated and may limit seriously the performance of a system. In this case, the responsibility for its successful operation rests clearly with the machinery designer.

As indicated earlier, Fig. 2 is a simple closed-loop system shown in schematic form. This is a perfect system without all the complexities and realities of life. Fig. 4 shows what the system just discussed looks like when they are incorporated. The command or desired value comes from the template and the tracer, which picks up this command, is represented by the reference input elements. Any error created by not properly translating this position signal into an electric reference signal cannot be taken out by the rest of the control system. This type of error or tolerance should be included in the control specifications. The reference input is compared with the feedback signal at the summing point and the difference or actuating error controls the systems elements. The control systems then operate to minimize this actuating error.

However, because of many of the mechanical ties, the quantity which ultimately must be controlled is controlled indirectly by the external controlled system elements. Errors that might be caused due to deflection, backlash, vibration, load disturbance, etc., are within the closed control loop and are minimized by the regulating action of the system. However, they definitely limit performance. Vibrations and deflections in tool holder, tool, etc., are among the indirectly controlled variables and cannot be minimized by the system. Since the system involved so many parameters—some mechanical, some electrical—it is obviously meaningless to specify system performance without giving due consideration to both mechanical and electrical components. Here the importance of performance specifications helps determine the responsibility of each party and so again demonstrates the need for common terms, definitions, and standards of performance which can be understood and used.

These are common problems with which user and manufacturer alike must contend. It does not have to be a position regulator system such as this contouring control. It may be a simple device or speed regulator, or a color-register control like those already discussed. For self-protection, performance specifications are necessary, whether you are a user or a manufacturer. You need to know for what you are committed and where your responsibility ends. If progress in this direction is to be made, it is then important that more thought be given and more action taken in establishing definitions and standards for general use. Free discussion in Section meetings and work by AIEE toward common definitions is one positive step. The other is for users and manufacturers alike to learn more about their own problems and to assist in setting up these standards of performance so that progress toward the common goal of better understanding, and ultimately greater progress in industrial electronics can be realized.

Jet Engine Performance Checked in Six Huge Test Cells

Six huge concrete and steel test cells, the jet engine laboratory of the Ford Aircraft Engine Division, Chicago, Ill., check performance of the U. S. Air Force's most powerful jet engines before releasing them for service. The test array, two engineering cells and four production cells, covers 46,200 square feet and has exhaust stacks as high as an 8-story building. Each cell has unique sound baffles to reduce the roar of *J-57* jet engines.

Each of the cells is operated remotely through an intricate control system developed by Ford in collaboration with engineers from Minneapolis-Honeywell's Industrial Division. A complex wiring system links some 60-odd automatic instruments, level indicator, alarms, recorders, controllers, and indicators, with the control rooms. Here, protected by 2-foot-thick concrete walls, engineers can watch the engine under test through a small window of double-strength bulletproof glass (see illustration at right). One instrument permits the engineer to take 48 temperature readings by merely depressing push buttons.

Engines to be tested in the cells are started by remote control and draw in their own air supply through a 15-foot door in the ceiling. The engine's exhaust travels down a horizontal tunnel 60 feet long, receiving blasts of cool air from special intake ports during the journey. At the tunnel's end is a chamber about 40 feet in diameter where the exhaust gases swirl and cool still further before starting up the 75-foot stack. Special baffles reduce the noise to a whisper on the way to the stack opening. When the engine is turned off the air intake door closes and a special air-conditioning system swings into operation, exhausting the last traces of carbon monoxide from the test cell before engineers enter for visual checks of the powerful engine.

Four of the test cells are used for actual performance checks of the engines as they come from the assembly lines; the other two are used for special engineering tests.

Harmonic Due to Slots in Electric Machines

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SLOTS HAVE BEEN a known source of harmonics in electric machines for many years. Almost as long as engineers have been designing synchronous generators, they have attempted to suppress slot harmonics in the output waveform. Because of the complex nature of this problem most of the previous work in this field has been of an empirical or semiempirical nature. Recent developments in the digital computer field have made a direct frontal assault on this long standing problem feasible. Further, use of the digital computer makes it possible to determine the optimum machine from a fairly large number of proposed designs. The approach to this problem developed in this article is particularly designed for solution of the problem by digital techniques which can be handled by most punched-card digital computers.

Assuming that the rotor has a coil or set of coils which provide the operating flux for the machine, then the air gap flux density will be proportional to the mmf developed on the rotor surface times the permeance of the air gap. It is assumed that the entire mmf generated appears across the air gap. This mmf can be expressed as a Fourier series in terms of the rotor co-ordinates. However, the permeance of the air gap cannot be expressed in a single variable Fourier series. If x represents the angular distance around the rotor and if y represents the angular distance around the stator, then the Fourier series for the air gap permeance for rotating machines can be expressed as follows:

$$P(x, y) = \sum_{n=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} P_{nm} \operatorname{Cos}(nx+my) + P'_{nm} \sin(nx+my) \qquad (1)$$

where P_{nm} and P'_{nm} are Fourier coefficients and n and m are integers.

At a fixed rotor position the permeance function can be expressed as a Fourier series of a single variable. In the past literature, there have been a number of papers which develop a means for determining the permeance function for a fixed rotor position.[1] This series representing the permeance function, however, is not the complete solution of equation 1. The complete solution can be effected by determining the permeance function at a large number of unique rotor positions and then establishing a series of simultaneous equations for each permeance harmonic. By this method the evaluation of the undetermined coefficients in equation 1 is a large-scale computation, so large that a high-speed electronic digital computer would be needed.

Fortunately, a simplifying assumption will reduce the problem so that in most cases the permeance function need be determined at only one rotor position. With this assumption, the solution can be obtained through use of the more common punched-card digital computer. The assumption is that there exists in any machine a magnetic equipotential surface of cylindrical form in the air gap of the machine. This assumption is well founded for machines with semiclosed slots and some technical writers have used this assumption very effectively for all types of machines.

With this assumption the air gap permeance can be written as follows:

$$P(x, y) = \sum_{n=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} P_{nm} \cos(nS_r x + mS_s y) + P'_{nm} \sin(nS_r x + mS_s y) \qquad (2)$$

where S_r and S_s are the number of rotor slots and stator slots. Equation 2 was developed by first expressing the effective length of the air gap as the summation of two independent Fourier series, one representing the rotor effective air gap length and the other stator effective air gap length. The permeance is proportional to the reciprocal of the summation of these effective lengths. This reciprocal can be determined by using a binomial expansion method.

A study of the method of deriving equation 2 shows that the coefficients of equation 2 can be arranged in an array which will reveal their approximate relative magnitude and the number of fixed rotor position permeance expressions required to obtain the general solution. In most cases the permeance expression for one rotor position is all that is required to arrive at a sufficiently accurate general expression for the air gap permeance. A study of the arguments of equation 2 will reveal the permeance harmonics which will affect the machine performance. In general, a study of equation 2 will reduce the problem to one whose solution is accomplished readily by punched-card computer techniques.

The preceding method for determining the permeance function makes it possible to set up a systematic approach using the punched cards. Once this permeance has been expressed as a Fourier series it then is possible to compute the air gap flux density by means of a term by term expansion of the product of the Fourier series representing the rotor mmf and the Fourier series representing the permeance function. This expansion also is handled readily by punched-card techniques. Finally, once the Fourier series for the air gap flux density has been defined, the voltage induced in stator windings, rotor bars, or other configurations may be ascertained by applying suitable harmonic reduction factors.

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Industry Co-ordination of Microwave Communications Systems

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In view of the directive radiation characteristics of microwave antenna systems, co-ordination solutions on a beamwidth basis together with frequency and bandwidth should be found to provide interference-free operation for a maximum of microwave systems in various areas. Independent physical surveys and studies are recommended as desirable steps towards optimum choice of microwave system design and routing.

THERE ARE AREAS appearing in the United States where special co-ordination consideration must now be given to future installation of microwave systems in order to avoid interference. Some of these areas are in the Valley Forge, Pa., Houston, Tex., and Kansas City, Mo., vicinities.

Because of the importance of hilltop locations, these and other areas rapidly are reaching a point of band saturation, especially where such hilltops are few in number and their positions make them suitable. Furthermore, fixed points for communication requirements are often in the same city or in close proximity for different companies in the safety, transportation, and industrial services. Consequently, the beamwidth patterns may overlap and cause need for separate frequencies in the same or other commercial bands.

In the Valley Forge area there are three separate microwave systems, namely those of the Keystone Pipe Line Company, the Texas Eastern Transmission Corporation, and the Transcontinental Pipe Line Company—all in the 1,850–1,990-mc commercial band. In an area of approximately 10 miles square there are five stations: two repeaters with three directions each, one repeater with two directions, and two terminals, requiring a total of 10 2-way r-f channels in the 1,850–1,990-mc band. To satisfy this requirement all but four frequencies available in this band were used and it is doubtful if these four can be used in the future in view of possible receiver image interference.

Careful study was made of beamwidth pattern interference in this area and maximum guard angles were used in choosing the frequencies to allow for sidelobe and overshoot interferences from and to antennas having 1/2-power beamwidths of 5 to 6 degrees. Safety factors for misfocusing of the dipole elements and for beamwidth azimuth movement, due to wind and ice forces on the paraboloids and towers, were other reasons for choosing separated frequencies to reduce interference possibilities.

In the Houston–Galveston area, there are five separate commercial microwave systems; namely, for the Trunkline Gas Company and the Transcontinental Pipe Line Company in the 1,850–1,990-mc band and for the Humble Pipeline Company, the Texas-Illinois Pipe Line Company, and the Santa Fe Railroad in the 6,575–6,875-mc band.

Had these systems been chosen to operate in the same frequency band, careful "juggling" of the different frequencies would have been necessary to avoid interference. Restricted beamwidth patterns with guard angles may have been necessary to allow use of the same transmit or receive frequencies. Since Houston is a focal station point, it is conceivable that in the near future new systems installed in this area may require use of one frequency band in the Houston vicinity and another frequency band in outside less congested areas. At that time special co-ordination survey studies will become a necessity.

In the Kansas City area, there are three separate commercial microwave systems; namely, for the Platte Pipe Line Company, the Sinclair Pipe Line Company, and the Panhandle Eastern Pipeline Company, all in the 6,575–6,875-mc band. Although this band is 300 mc wide as compared to 140 mc for the 1,850–1,990-mc band, the use of passive reflectors requires four separate frequencies for transmitting and receiving at a repeater station. Requiring at least 40-mc separation between transmit frequencies and 120-mc separation between transmit and receive frequencies, systems of this type use more band frequencies especially if the beamwidth patterns overlap and require separate frequencies.

Kansas City is a typical growing industrial center. Pipeline companies, together with power companies, railroads, turnpikes, and other eligible industries, are planning microwave systems in or around areas of this nature. Without co-ordination of microwave frequencies and beamwidth patterns, interferences and confusion will result which will reduce greatly the utilization of the bands now available on a shared basis. Other areas which also are rapidly approaching a point of concern for co-ordination in the 1,900- and 6,700-mc bands are around Los Angeles, Calif., St. Louis, Mo., and New York, N. Y.

POTENTIAL SYSTEM APPLICATION

THE POSSIBILITIES of microwave communication system application are unlimited and are broad in scope. These possibilities exist because microwave serves as a main highway for many varied forms of communication required by many different industry and safety groups, now required

Full text of paper **54-188**, "Industry Co-ordination of Microwave Communications Systems," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE North Eastern District Meeting, Schenectady, N. Y., May 5–7, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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to share the frequencies available in the commercial bands of 952–960 mc, 1,850–1,990 mc, 2,110–2,200 mc, 2,450–2,700 mc, 6,575–6,875 mc, and 12,200–12,700 mc.

With progress, the number of interested users will grow and so will the number of systems installed, whether they be privately owned or leased from the suppliers or leased as private systems from the telephone utility companies. Proper methods of co-ordination and control therefore must be set up now to allow for systematic and best use of the limited frequencies available for these broadband types of microwave applications.

At the present time, all licenses granted are on a developmental basis and all frequencies in the commercial microwave bands are on a shared basis. Service eligibility is limited generally to the groups now eligible for regular fixed and mobile radio service. Applications from other organizations such as special industrial and service organizations are considered separately on their relative importance and need. Equivalent service through use of common carrier facilities by microwave, cable, or wire is a factor in consideration of applicants not eligible specifically in the Federal Communications Commission (FCC) rules and regulations.

For reasons that the frequency bands available allow for few 2-way r-f channels with adequate bandwidth and since the beamwidth patterns are highly directive instead of omnidirectional or wide in nature, it is unlikely that microwave frequencies will be allocated in the future on a separate industry group basis as in mobile radio.

LICENSING PROBLEMS

Since licenses are granted on a developmental basis, full standards have yet to be established for microwave systems and the industry has had to get along on the various technical standards recommended by the manufacturers and laboratories supplying the equipment.

Frequency recommendations, frequency stability, power output, bandwidths, and type emission are given for the manufacturer's type of equipment and usually accepted by the FCC in its developmental grant for construction and operation of microwave stations.

Microwave communication systems installed to date and those now available from the different manufacturers vary widely as to the type of antenna systems, r-f equipment, frequency stability, r-f bandwidth, and multiplexing. Installations are growing on a "first come, first serve basis in the area" and later arrivals will find it difficult to fit into existing un-co-ordinated situations of different frequency separations, different bandwidths together with variations in antenna directivity and sidelobe tolerances.

Because of this growing confusion, there is considerable activity by various industry groups in the direction of standardization and establishment of a permanent set of rules and regulations by the FCC. Before this can be done, however, a number of factors must be considered. Effect on existing installed systems, eligibility of other possible users, extra engineering design costs by manufacturers, methods of controlling and recording beamwidths and guard angles, possible bandwidth packages for voice channel requirements, joint industry co-ordination administration procedures, system licensing instead of station licensing, field survey analyses and independent certification, these and other factors are under discussion in the "shifting of gears" from temporary to permanent licensing.

SPECTRUM UTILIZATION

Edwin L. White, chief, Safety and Special Services Bureau, FCC, gave a paper in Houston on April 9, 1953 at the Petroleum Industry Electrical Association meeting on the subject of "The Future of Microwaves." In his speech, he introduced the possibility of frequency assignments based on geometry rather than frequency or service category. By this, he meant the sharing of frequencies with assignment of beamwidth patterns in the same area, thus increasing the number of potential r-f channels in any one area. He indicated that such an arrangement could be successful only if the best engineering techniques were applied to the directive antenna systems, their supporting structures, and also the associated r-f and multiplex electronic equipment.

To continue his discussion, consider what some of the system conditions are that these "best engineering techniques" must strive for to realize optimum spectrum utilization.

SYSTEM CONDITIONS

R-F Bandwidth and Ultimate Multiplex Channels. A desired situation on bandwidth would be one where the assigned bandwidth would be the minimum for the ultimate number of multiplex telephone channels authorized for a potential user. This would allow for systematic grouping of the r-f carrier frequencies in each commercial band consistent with the user's present and future needs.

For example, it would make frequency assignments much easier if r-f bandwidth could grow with channel packages of 4, 8, 16, 24, and 30 telephone channels. Channel bandwidths could be set aside in each band for these packages. Potential users would be required to justify their need for telephone capacity at the time of license application.

Maximum Frequency Stability. The highest order of frequency stability, consistent with available tubes and circuitry technique, is desirable. This minimizes the total r-f transmitter deviation from the assigned carrier frequency and allows for narrower receiver bandwidths. Direct crystal control, automatic-frequency-controlled circuits, or temperature-controlled oscillators realizing results of at least 0.01 per cent stability or better should be strived for.

Minimum and Restricted Beamwidths. Use of antenna and reflecting surfaces whose radiated energy is confined within a minimum specified radiated cone is desired in order to allow azimuth assignments of transmission and reception.

Consistent with practical costs of tower supporting structures, the maximum 1/2-power beamwidths allowed should be in the order of 4 degrees in the 1,900-mc band and 2 degrees in the 6,700-mc band. Guard angles on each side of the 3-db points should be not more than 15 degrees, at which outside points the signal level of sidelobe radiations, should be at least 40 db down from the main radiation.

Where antennas are mounted on supporting structures

that are subject to twist and deflection, a method of measurement, giving a continuous record of the azimuth movement of the radiated beam, should be provided. All supporting structures should be so designed as to not twist more than the 1/2-power beamwidth under maximum wind conditions for the area. This would be necessary in order to prevent interference between adjacent beamwidth patterns during high wind conditions.

Minimum System Frequencies. Antenna systems should be designed so as to require use of a minimum of frequencies for transmit and receive at a repeater station. This may be difficult to do with some antenna systems but should be a requirement to strive for in all frequency bands.

Practical Co-ordination Problems. Microwave co-ordination in the commercial bands would be much easier if the afore-mentioned desired conditions discussed existed today, but they do not. Through the process of free competition, pressure from industry groups, self control, and government guidance, it is believed that a co-ordinated group of microwave systems and area plans will evolve, which eventually will provide for the most efficient use of the spectrum.

Co-ordination today, however, is faced with utilizing the present variety of practices and analyzing applications of present microwave equipments. To co-ordinate system usage on the basis of exclusive frequency assignment in an area would be using the "line of least resistance" and would not be in the public interest. On the other hand, frequency assignment plans, based on a geographic basis, bring up many practical problems. The following will analyze a few of these practical problems that experiences have brought to light in the past several years.

PRACTICAL PROBLEMS

Frequency Assignments and Overshoot Interference. Overshoot interference as a result of abnormal refraction phenonema usually makes it necessary to assign alternate frequencies to a line of repeater stations in the same system; when new stations are located in an area by other users, possibilities of overshoot interference from other areas may result if the antenna orientation is approximately in line and the frequencies are the same.

This is contrary to the expected "line of sight only" properties of microwave propagation. At times these overshoot signals may be stronger than the direct signal. Polarization and beamwidth changes in the antennas are of some help but do not give complete rejection. In most cases, it will be important that initial field surveys be made to determine which group of frequency assignments, which frequency band, and possibly which type of multiplexing best would fit the locations contemplated. Often, these locations may be fixed as a result of communications requirements.

Antenna Sizes, Beamwidths, and Path Lengths. Most systems today are designed on the basis of having adequate reserve gain to allow for fading and maintenance margins. This usually means using higher gain antennas for long path lengths. Beamwidths become smaller with increase in antenna gain and larger with decrease in antenna gain. Paraboloid antenna areas increase with gain and naturally the assemblies become more costly with size. For short path lengths, then, small antennas with wide beamwidths up to 20 degrees, having sufficient gain, have been used for both economical and technical reasons.

As the azimuth space in an area becomes occupied, it may be necessary that all antenna 1/2-power beamwidths be restricted to the smallest practical width for the particular frequency band. For example, at 1,900 mc, a 2-foot paraboloid has a beamwidth of approximately 18 degrees whereas a 10-foot paraboloid has a beamwidth of approximately 3.5 degrees. Similarly at 6,700 mc, the beamwidths are approximately 5 degrees for a 2-foot paraboloid and under 2 degrees for a 6-foot paraboloid. Co-ordination faces the problem of what to do with antennas already installed with wide beams in conjested areas.

Antenna Beamwidth Control and Tower Costs. It may be easy to state that beamwidths should be as narrow as possible in order to allow for more sharing of frequencies in an area, but will it be practical to keep these beamwidths contained within narrow limits, especially in areas of above-average wind velocities?

Experience has shown that twist and deflection tolerances of ± 1 degree and ± 0.5 degree respectively, are reasonable under conditions of 30 pounds per square foot wind loading and 0.5 inch of ice loading, provided the tower heights are not much over 300 feet.

Measuring and logging the azimuth movement of an antenna and its supporting structure in order to control and allow close adjacent-space operation of another beam, however, is a problem. Various methods have been suggested, such as the light-beam method which uses a collimated beam of light from the tower to a calibrated graph that is continually photographed for a permanent record of the tower twist and deflection.

Co-ordination will require that an acceptable method of measurement be used or that independent engineering certification of tower rigidity and deflection tolerances be made as a part of beamwidth space assignments.

Back-to-Back and Reflection Interferences. The radiating and rejection characteristics of paraboloid antennas and passive reflectors are such that sidelobe interferences are possible. Unexpected received signals from reflecting hills or buildings or even from similar strong radiating antennas, 180 degrees away, often can upset what appears to be a logical frequency assignment for the receiving station. Changes in polarization and beamwidth offer some help in reducing this type of interference.

If possible, it would be desirable that antenna reflecting surfaces be improved and that the assemblies be tuned or focused more accurately for each particular frequency. Reduction of sidelobes would assist in lessening the guard angles between adjacent beams of the same frequencies.

In the 1,900-mc band, for example, at a backbone and sidehop station, there are not too many cases where the same receiving frequency is used for all three directions, unless the guard angle between beam directions is at least 80 to 90 degrees. This is because of the wanted additional safety factor against poor rejection by adjacent antennas.

In the 6,700-mc band where passive reflectors are em-

ployed, it becomes very difficult to use the same frequency in even two directions which are 180 degrees apart. Back-to-back interferences at a repeater require separate frequencies for each direction, thus utilizing more of the frequency spectrum.

These and other similar interference problems will require considerable study for better co-ordination results. In congested areas, prior path testing in the different frequency bands and with different type antennas may be necessary to assure the best possible use of the limited frequencies available.

Location Procurement and Accessibility. One of the problems about which little can be done is location availability and the economic factors of power and roads. A pattern of frequency assignments based on specific beamwidth patterns may be well planned to avoid interferences, but may not be possible to put into effect. Right-of-way and easements may be difficult or impossible to obtain for the planned locations.

This problem stresses the importance of initial engineering and independent field surveys to enable the potential user and the co-ordination group to make best decisions as to frequency assignments prior to equipment purchase. It is also advisable that the potential user reserve his decision as to which commercial equipment to purchase until he has the answer to his land and location problem.

R-F BANDWIDTH, FREQUENCY STABILITY, AND MULTIPLEXING SYSTEMS

THE CO-ORDINATION PROBLEM here is complex because of the lack of standardization in system design and because of the several different commercial frequency bands available. Competitive forces, a large potential market, and the false feeling of no foreseeable congestion in the microwave bands probably will continue to keep alive these various differences.

Briefly, there now are available eight different type systems, from General Electric, Motorola, Radio Corporation of America, Westinghouse, Federal, Collins, Philco, and Automatic Electric, with several other companies planning new systems soon to be released. Each of these systems has its relative advantages and disadvantages for particular applications. Until recently little thought has been given to co-ordination of different systems in the same area. As a result a common allocation plan of r-f carrier-frequencies and bandwidths will be difficult to arrive at unless some re-engineering of equipment is done.

An analysis of these various systems will show, however, that it may be practical to group them into bandwidth versus number of multiplex channels. For example, in a case where the ultimate need of telephone channels is only four, the systems authorized for licensing would be those requiring a minimum bandwidth for these four channels.

Following this line of reasoning, perhaps a division of systems into those most suitable for 5-mc operation, including the guard bands, and for 10 mc, including the guard bands, would be a logical solution towards the most efficient use of the spectrum bandwidth versus type of multiplex system, method of modulation, and frequency stability.

In this way it would allow assignment of a minimum required amount of bandwidth to qualified applicants and would permit them to engineer and purchase the system that makes the most efficient use of bandwith.

USER CO-ORDINATION

THERE HAS been formed recently a joint industry group called the Microwave Users Council. This Council represents some 16 radio service groups in the category of safety and special services, such as the petroleum, power, railroad, forestry, police, highway, etc. The Council will serve as a clearinghouse of information on installed and proposed noncommon-carrier microwave communication systems. This information will be available to the prospective user and his engineer or consultant engaged in the planning of a new microwave system. For assurance that the type and routing of microwave system planned is properly co-ordinated as to interference and future growth, it is advisable that an independent physical survey and study be performed to indicate the most suitable frequency band and the most appropriate microwave equipment for the application.

Batteries Serve Double Purpose on Railroad Dome Cars

Lighting and air conditioning have been given careful consideration on the new full-length dome cars built by the Budd Company for the Santa Fe Railway. Because of the great amount of space exposed to the sun by the full-length dome and the drastic changes in temperature in the mountains and desert, there are two cooling and heating units in the dome car. The air-conditioning unit in the dome cars is large enough to air-condition seven average sized homes.

Car lighting and air conditioning are powered by a 70-hp diesel engine. During emergencies, the lights are kept in operation by a large battery furnished by Gould-National Batteries, Inc. The battery also is used to start the diesel engine.

These Gould batteries supply power to start the large diesel engine used on the dome cars for air conditioning and car lighting. They also keep lights going during emergencies

Calculation of Life Characteristics of Insulation

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INSULATION AGING DATA frequently are presented by plotting the reciprocal of the absolute aging temperature as abscissa and the logarithm of the aging time to failure as ordinate. This gives concise and useful information but often the design engineer requires this information in other forms; for example, aging at a constant temperature or perhaps at a different level of degradation.

Based on chemical reaction rate theory and assuming that the physical property measured is a function of time, is proportional to a constituent that is a measure of insulation deterioration, and is a first-order reaction; equations may be derived which convert the aging data to these other forms.

If the aging data are plotted in terms of deterioration of dielectric strength to some specified level, the general equation can be shown to be

$$\log_\epsilon D.S. = -At\epsilon^{-E/RT} + C \qquad (1)$$

where

$D.S.$ = dielectric strength
t = aging time
T = temperature in degrees absolute
A = frequency factor of molecular encounter
E = activation energy (a constant for a particular reaction)
R = universal gas constant
C = integration constant ($\log_\epsilon D.S.$ at $t=0$)

In these same terms the equation giving the relation between per cent dielectric strength, temperature, and hours to breakdown can be derived from equation 1.

$$\log_\epsilon t = \log_\epsilon\left[\log_\epsilon\left(\frac{100}{\%\ D.S.}\right)\right] - \log_\epsilon A + E/RT \qquad (2)$$

For polyethylene terephthalate the constants have been determined from a plot of the test data. These substituted in equation 1 give

$$\log_\epsilon D.S. = -3.47\times10^{10} t\epsilon^{\frac{-1.37\times10^4}{T}} + 8.10 \qquad (3)$$

Similarly equation 2 gives

$$\log_\epsilon t = \log_\epsilon\left[\log_\epsilon\left(\frac{100}{\%\ D.S.}\right)\right] - 24.270 + \frac{13,700}{T} \qquad (4)$$

In Fig. 1, the full line curve labeled 50 per cent gives the least mean squares curve of the original test data and dotted curves give results of equation 4 for degradation to various percentages of $D.S.$ Comparison of the 66.6-per-cent dotted curve and test points labeled 66.0 per cent show the good agreement between calculation and test for limited data (calculations based on the 50-per-cent curve). Constant temperature curves for polyethylene terephthalate also may be plotted from equation 3.

The aging curves for silicone-impregnated asbestos insulation also have been computed and plotted and show reasonable relationships for this insulation which is removed considerably in temperature characteristics, dielectric strength, and thickness from polyethylene terephthalate.

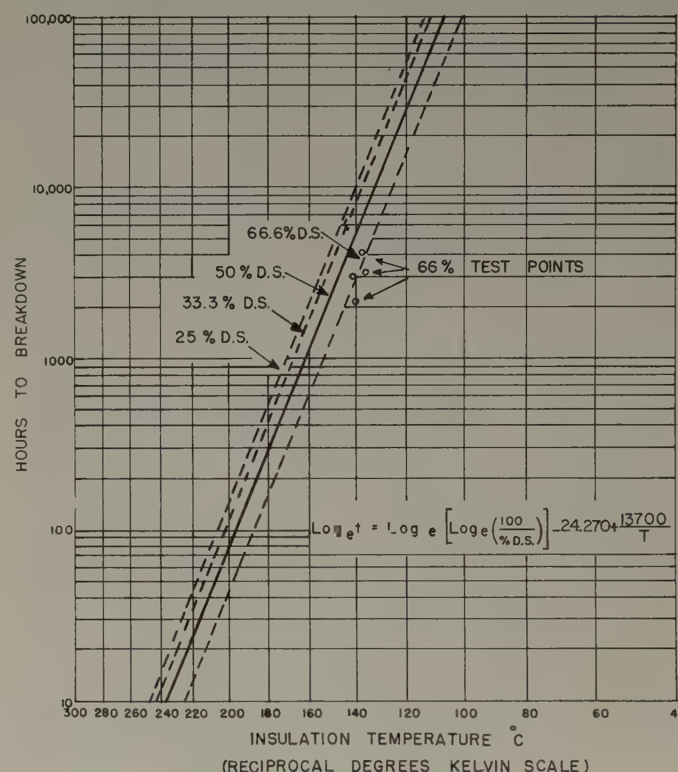

Fig. 1. Calculated and tested life characteristics of polyethylene terephthalate film in air at various dielectric strength criteria

In selecting a per-cent dielectric strength criterion there will be a minimum lower limit that can be used. This mimimum is reached when the breakdown criterion becomes equal to the electrical strength of an equal thickness of air.

Conclusions are

1. A method is available for converting time-temperature insulation characteristic curves to insulation aging characteristics at a constant temperature.
2. Insulation aging curves at one level of degradation may be extended to other levels if a first-order reaction exists.
3. Limited tests on polyethylene terephthalate (Mylar) at different percentage criteria confirm the correctness of this method for this type of material.

Digest of paper 54-72, "Calculation of Life Characteristics of Insulation," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Measuring Transmission-Line Impulse Voltages

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THREE companion papers describe impulse tests performed on the experimental transmission lines of the American Gas and Electric Company.[1-3] When these tests were being planned, it was necessary to select voltage dividers capable of reducing the high-surge voltages to a level suitable for measurement by a cathode-ray oscillograph. Selecting dividers for measuring transmission-line surges is complicated by the necessity of obtaining a high divider impedance to prevent excessive reflections on the line while maintaining an acceptable divider response.

The sources of error affecting the response of the resistance-type divider were determined by laboratory measurements. The resistor units, though formed of two oppositely wound coils, were found to possess an inductance of about 5 microhenrys per foot. The divider was found to have a stray capacitance to ground of 5 micromicrofarads per foot. The resistance of the individual resistor units departed appreciably from the d-c value at frequencies above 3 mc.

The frequency response of the 12,000-ohm 12-foot resistance-type divider was measured in the laboratory and is shown in curve *A* of Fig. 1. The calculated frequency response based upon the determined circuit constants is shown as curve *B*. The divider constants were assumed to be truly distributed, and calculations were based on conventional transmission-line equations. Curve *C* shows the frequency response calculated with the stray capacitance assumed to be the only active source of error. Comparing curves *A*, *B*, and *C* shows good agreement between the measured and calculated response curves, and further shows that the stray capacitance to ground is the controlling source of error affecting the response characteristics. Various attempts were made to overcome the effect of this stray capacitance to ground.

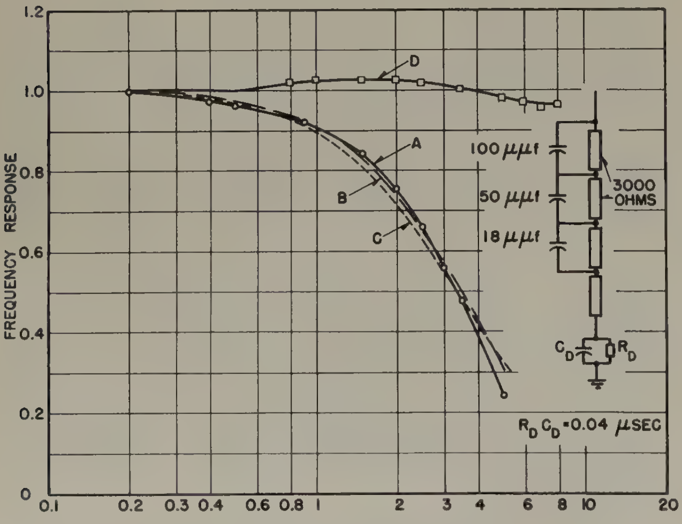

Fig. 1. Experimental and calculated frequency response for a 12,000-ohm 12-foot resistance divider with and without tapered-capacitance compensation. Inset shows physical form of compensated divider

Curve A—Experimental; uncompensated divider
Curve B—Calculated; uncompensated divider
Curve C—Calculated; uncompensated divider with inductance and resistance change with frequency neglected
Curve D—Experimental; compensated divider

Response errors caused by stray capacitance to ground result from the necessity of supplying charging current through the relatively high series resistance. This error can be corrected if each element of resistance is paralleled by capacitance just large enough to supply charging current for all the units below. While in theory, this "tapered-capacitance" compensation requires the addition of truly distributed capacitance, the correction can be approximated by the addition of lumped capacitors shown in the inset of Fig. 1. When that compensation was applied, the measured response curve *D* was obtained. The response is essentially flat to at least 8 mc where the measuring circuit became unreliable. It is apparent that the response of the 12,000-ohm 12-foot divider has been much improved by adding of tapered-capacitance compensation.

It is significant that compensation has been obtained with the addition of a small capacitive loading as viewed from the high-voltage terminal of the divider. The improved response characteristic, then, has been obtained without sacrificing the high impedance of the divider.

To gain an insight into the relative effects of the different sources of error, frequency response curves for resistance-type dividers of various lengths and total resistances were calculated using estimated circuit constants. The calculations revealed that for physically long, high-resistance dividers, the principal source of response error is the stray capacitance to ground. For short dividers of low resistance, the major source of error is the resistance variation with frequency. For dividers of intermediate length and resistance the response is affected by all error sources.

The response can be improved by decreasing the length of the divider as much as possible. In general the response can be improved by decreasing the total resistance.

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Long-Time Scale Models of Transformers for the Determination of Transient Voltages

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The long-time scale model is particularly advantageous for detailed and thorough studies requiring measurements at a large number of points, with a variety of applied waves, winding terminations, and connections. Such studies are indispensable for the correct design of the insulation in modern large high-voltage power transformers. The applications of these models include design and development, improvement of present designs to establish uniform safety factors, investigation and modification of new structures and winding arrangements, and in special cases determination of which structure is best suited to meet customer specifications.

KNOWLEDGE of transient voltages is very important for transformer design, in particular for the design of modern large high-voltage power transformers. Transformer designers need to know the maximum voltages and also the waveshapes between a great number of points of greatly diversified structures and for a wide range of applied waves, winding connections, and terminations to effect the most economical design.

Since it is definitely impractical, and sometimes impossible, to compute by purely analytical means all the transient voltages, the electromagnetic model[1] was developed to furnish directly all answers required for transformer design and development. In the electromagnetic model all points of interest are readily available, many more than in the original transformer. All types of impulse waves, connections, and terminations are reproduced readily. The accuracy of the electromagnetic model is entirely adequate for design purposes and, in fact, such models now are being used extensively for the design and development of power transformers. The unity-time scale models previously described are tested with the transient analyzer[2] just as the transformers themselves.

It must be realized that the manner of presentation of the design information is almost as important as the accuracy of that information. In fact, transformer designers must consider simultaneously all transformer characteristics (losses, reactance, cooling, noise, etc.) for a correct, well-balanced, and well-integrated design. The electrical stress information must be handed to the designers in the form most useful for their work. For instance, tables with cross-references to winding sketches on separate sheets are hard to digest in a short time. On the contrary, plots of maximum voltages to ground versus per-cent winding, maximum gradients versus per-cent winding, voltages between windings versus axial height, voltage distributions at fixed times, and the like, are extremely useful for clear visualization and quick grasp of the phenomena and for making at once definite design decisions.

When measuring transients in the conventional manner the relation of only two variables is obtained for each measurement, usually voltage difference versus time. A number of oscillograms must be obtained for each point of the winding to be investigated. These films then are analyzed and scaled and the information is plotted in the form of the desired curves. In many cases the preparation of the data in simple, concise form requires more time than obtaining the original data. It is evident that if the required plots could be obtained automatically, a great deal of time and labor would be saved, the possibility of errors would be reduced, and much more information could be furnished to the designer with less effort.

To summarize, the first step in the development of electromagnetic models was to prove that such models are feasible and economical, and that they yield all design information with the required accuracy. The second step, which is equally important in practice, is the rapid presentation of this information in the manner most useful to the designer. This second step has been accomplished with the long-time scale electromagnetic model, wherein all transient phenomena in the transformer are reproduced accurately, but are slowed down very considerably.

THE LONG-TIME SCALE MODEL

ORIGINALLY, electromagnetic models of transformers were built with time scales close to unity, say from 0.5:1 to 2:1, because this initially appeared to be the simplest approach and because they could be tested with the same equipment and in the same manner as power transformers. However, the great advantage of a long-time scale model, say with a time scale ranging from 50:1 to 1,000:1 or even more, was not overlooked. The time scale t is a function of the inductance scale L and of the capacitance scale C

$$t=\sqrt{LC}$$

Usually in a long-time scale model both the inductances

An abridged text of paper **54-117**, "Long-Time Scale Models of Transformers for the Determination of Transient Voltages," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Publiished in AIEE *Power Apparatus and Systems*, April 1954, pp. 345–53.

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The authors gratefully acknowledge the encouragement and assistance received from many of their associates in the General Electric Company, in particular D. D. MacCarthy, J. H. Hagenguth, and A. F. Rohlfs. All tests on the models and the original ransformers were conducted by the staff of the high-voltage engineering laboratory.

Fig. 1. Long-time scale model of 30,000-kva transformer: 138 kv (delta-connected) to 69 kv (Y-connected) and slow-speed transient analyzer

and the capacitances must be many times larger than in the transformer. Therefore all lead inductances and capacitances, as well as the capacitances of the measuring equipment, are negligible. This allows many measurements to be made automatically as will be explained later.

Just as the unity-time scale model previously described,[1] the long-time scale model consists of (see Fig. 1):

1. An equivalent circuit of lumped capacitances, which represents the capacitances between windings and between winding and ground.
2. A geometrical model of the windings, which represents the self- and mutual inductances of the windings.

In the unity-time scale model also the core is geometrically similar to the original. In the long-time scale model the depth of penetration of the magnetic flux into the core is greater than in the original, because of the much lower frequencies involved. Therefore the core of the long-time scale model has a smaller cross section than would be required by geometrical similitude. The model core window, however, is geometrically similar to the original.

Thus long-time scale models are very much like unity-time scale models, except that the core is lighter and simpler to build. The length scale may vary between wide limits depending on the size of the original and on the application of the model. Models at present have been built successfully with length scales varying between $l=1/2$ and $l=1/15$. Consequently, these model windings weigh between $l^3=1/8$ and $l^3=1/3{,}375$, that is between 12.5 per cent and 0.03 per cent of the original winding. The limits of the model core weights are lower than these values. Time scale varying between $t=30$ and $t=1{,}050$ have been used so far; but these limits are not definitive.

THE SLOW-SPEED TRANSIENT ANALYZER

Since the ordinary transient analyzer[2] cannot be used to test long-time scale models, a special slow-speed transient analyzer was built with several new features which allow the presentation and recording of all design information in a form immediately useful for transformer design. This was achieved by introducing the "third dimension" in transient analysis, that is, oscillograms showing voltage distributions versus space, or per-cent winding in addition to the usual voltage distributions versus time between fixed points. Since only low frequencies occur in slow-speed transient analysis it is possible to connect all measurement points of the model winding to the contacts of telephone-type stepping switches, because the lead inductance and capacitance cause no disturbance. With the aid of these switches the winding taps can be scanned rapidly in sequence and all types of voltages may be presented on an oscilloscope whose horizontal coordinate corresponds to per-cent winding. The most important type of oscillogram of this type is a plot of the maximum voltages either to ground or between points versus per-cent winding, see Figs. 2 and 3. This tells the designer at a glance what insulation is needed.

The structure of the vertical lines gives some indication as to the type of maximum voltage at the various points. For instance, a thin line of low intensity extending to the maximum indicates a voltage pulse of short duration, while a heavy line reaching to the top indicates that the voltage remained near the maximum value for a considerable length of time. This can be used to judge the severity of the stress on the dielectric whose strength depends both upon voltage and duration of the stress.

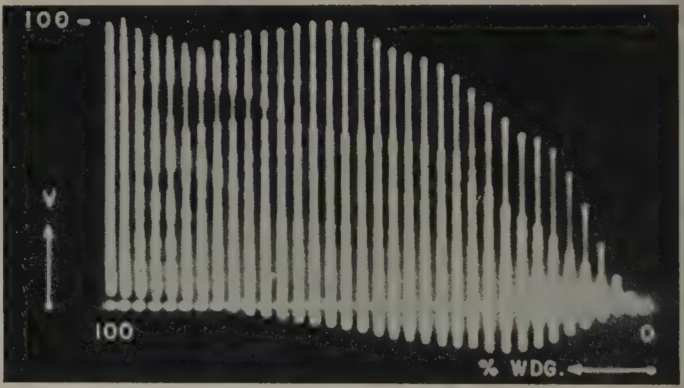


Fig. 2. Full-wave maximum voltages to ground in impulsed high-voltage winding of 30,000-kva transformer model

Fig. 3. Full-wave maximum voltages between adjacent cross-overs in impulsed high-voltage winding of 30,000-kva transformer model

Fig. 4. Initial distribution at 0.04 μs of voltages to ground in impulsed high-voltage winding of 30,000-kva transformer model

Instead of leaving the intensity of the electron beam high during the entire length of the impulse wave, the beam can be turned off except for a very short interval at a preset time after the occurrence of each impulse wave. The voltage at each point is essentially constant during such a short time interval and therefore a dot is obtained in place of a line. All these dots, however, line up to a curve which is called the "instantaneous voltage distribution" at the time when the intensity is flashed on. These instantaneous voltage distributions are valuable for theoretical studies of the propagation of impulse waves into transformer windings. The best known and most useful is the "initial distribution" measured at very short times, before the applied wave reaches crest, see Fig. 4.

Further use can be made of the scanning circuit by providing group exposures of impulse response waves. If the zero reference line of successive waves is lowered in steps, a startling 3-dimensional effect is obtained. Figs. 5 and 6 show at a glance the voltage distribution versus both space and time in the entire winding, traveling waves in certain cases, points of reflections, etc. They also are useful in keeping compact records of waveshapes which ordinarily are not needed. If a particular waveshape is desired it may be selected and retraced from one of the groups using a projector. Thus the number of oscillograms on file may be reduced considerably.

Another important innovation on the slow-speed analyzer is a built-in differential amplifier. The mutual signal suppression could be made as high as 1,000:1 for all frequencies of interest, thus permitting the measurement, with good accuracy, of the model voltages equivalent to voltages between individual turns at any point along a transformer winding. It also was possible to incorporate a much improved timing circuit into the new analyzer. This circuit produces regularly spaced time markers, "pips," of very short duration. The frequency of the pips is adjustable to represent a fixed interval, say 1 or 2 microseconds of equivalent transformer time, for any long-time scale. For easy time measurement, these markers can be superimposed directly on any oscillogram. A noticeable emphasis on each tenth marker affords further convenience in reading intervals larger than 10 or 20 microseconds, as shown on Fig. 7.

The slow-speed analyzer is able to generate—due to the extremely low impedance of the generator output—"ideal waves"; that is, impulse waves with extremely fast equivalent fronts and long tails. The new analyzer has an output of only 10 volts, to be compared with outputs of the order of 1,000 volts obtained with the ordinary analyzers. The low-voltage output is extremely advantageous from the standpoint of safety and accessibility of the model. In fact, various changes can be made on the model with power applied to it and the results observed immediately on the analyzer screens.

TRANSIENT VOLTAGES IN THE MODEL AND ORIGINAL

The slow-speed transient analyzer and a long-time scale model of the 30,000-kva transformer, with scale of lengths of 1/8:1 and time scale 35:1, are shown in Fig. 1. The electronic impulse generator and the two cathode-ray tubes are in the unit to the left, the scanner is in the unit at the center. The upper tube is used for voltage distributions versus space, the lower for voltage distributions versus time. Typical comparisons of full-wave voltages in the transformer and in the model are

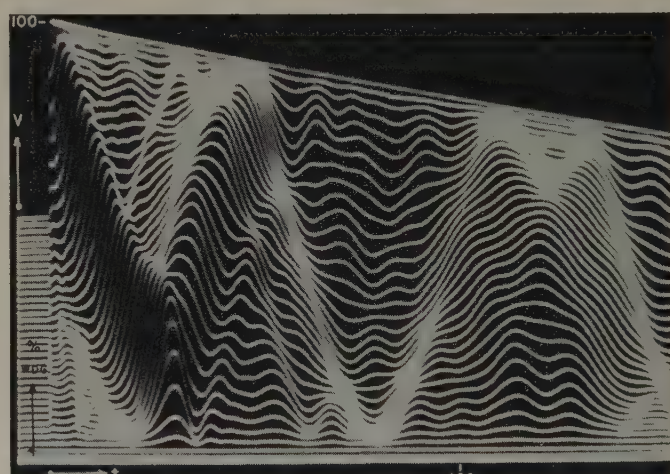


Fig. 5. Full-wave voltages to ground versus time and p-center winding in impulsed high-voltage winding of 30,000-kva transformer model

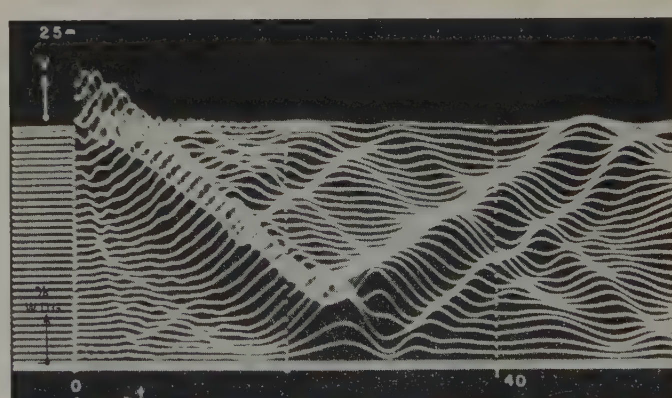


Fig. 6. Full-wave voltages between adjacent crossovers versus time and per-cent winding in impulsed high-voltage winding of 30,000-kva transformer model

shown in Figs. 8 and 9. Fig. 8 shows the voltages to ground at 50-per-cent winding, Fig. 9 the voltages between two taps, encompassing 2.5-per-cent winding, at the center of the winding. In both figures the time scale is the true time scale of the transformer and the voltage scale is expressed in per cent of the crest of the applied wave. It is evident that the model very faithfully reproduces the transformer response.

Long-time scale models have an accuracy which is comparable to the accuracy of the unity-time scale models.[1] This is shown by Table I, where deviations are given between values measured on the same prototypes and on long-time and unity-time scale models.

Table I. Summary of Deviations of Electromagnetic Models

Type of Voltages	Number of Points Measured	Long-Time Scale Models (1)	Long-Time Scale Models (2)	Unity-Time Scale Models (1)	Unity-Time Scale Models (2)
Voltages to ground	11	7.8	8.9	6.0	6.9
Across large parts (6 to 50 per cent) of impulsed winding	19	5.8	11.4	4.4	8.6
Across small parts (1 to 5 per cent) of impulsed winding	29	2.0	11.0	2.1	11.1
Transferred to nonimpulsed windings	4	3.7	10.8	5.1	15.0
Grand totals	63	4.0	10.7	3.7	9.8

(1) Average deviation, per cent of applied wave
(2) Average deviation, per cent of transformer voltage

The model deviation represents the per-cent difference in absolute value of the maximum voltages between two corresponding points of the model and of the transformer. In Table I the deviations are referred (1) to the applied wave taken as 100 per cent and (2) to the transformer voltage at the point considered as 100 per cent. The average deviation of the long-time scale models is 4.0 per cent of the applied voltage and 10.7 per cent of the transformer voltage, for a grand total of 63 points measured. The maximum deviations are of the order of two times the average deviation, and always less than three times. Such an accuracy is entirely adequate for the design of transformer insulation, for developmental studies, and for studies of system performance with transformer models.

Of interest for design and special applications is also the agreement of the natural frequencies of transformers and long-time scale models. As an example, in Table II are given the first five natural frequencies of a 667-kva transformer with grounded neutral and its model with time scale of 132, as well as the ratios of the higher harmonics to the fundamentals. The agreement between transformer and model is very good, particularly for the frequency ratios, which show a 3.2-per-cent average deviation.

Table II. Natural Frequencies (Kilocycles) of 667-Kva Transformer and Long-Time Scale Model

Harmonic	Transformer Freq.	Transformer Ratio	Model of Time Scale 132 Freq.	Model of Time Scale 132 Freq.×132	Model of Time Scale 132 Ratio
Fundamental	28	1	0.19	25	1
Second	92	3.3	0.58	77	3.1
Third	150	5.4	1.07	141	5.6
Fourth	250	8.9	1.66	220	8.7
Fifth	320	11.4	2.15	284	11.3
Average absolute deviation				11.2%	3.2%

It may be concluded therefore that long-time scale models, just as unity-time scale models, reproduce within engineering accuracy (1) the maximum voltage amplitudes, (2) the duration of the stresses, (3) the waveshapes, and (4) the frequencies of oscillation.

Typical Presentation of Design Information

A long-time scale model of a 3-phase 30,000-kva transformer, 138 kv (delta-connected) to 69 kv (Y-connected) is shown with the slow-speed analyzer in Fig. 1. Typical voltage distributions taken on this model are shown in Figs. 2 to 7. The applied full wave is shown on Fig. 7. The time markers, 20 microseconds (equivalent transformer time) apart, are clearly recognizable.

In Figs. 2 and 3, the vertical co-ordinate is voltage and the horizontal co-ordinate per-cent winding, from the grounded neutral end on the right (0 per cent) to the line end on the left (100 per cent). Maximum voltages to ground for full wave are shown on Fig. 2. Each trace represents the voltage at a given point, so that the upper and lower envelope of all traces is the maximum and minimum voltage distribution along the winding, at any time during the duration of the transients. As explained previously, the intensity of the trace is a measure of the duration of the stress. Fig. 3 shows the full-wave maximum voltages between adjacent crossovers, amplified five times. It is evident that while these stresses decrease in amplitude from the line to the neutral end, their duration increases, so that the equivalent stress across the ducts is almost uniform.

Of great interest are the 3-dimensional representations (voltage versus time and per-cent winding) of the voltages to gradients (voltages across 3-per-cent winding) for full wave, shown in Figs. 5 and 6 respectively. The fundamental

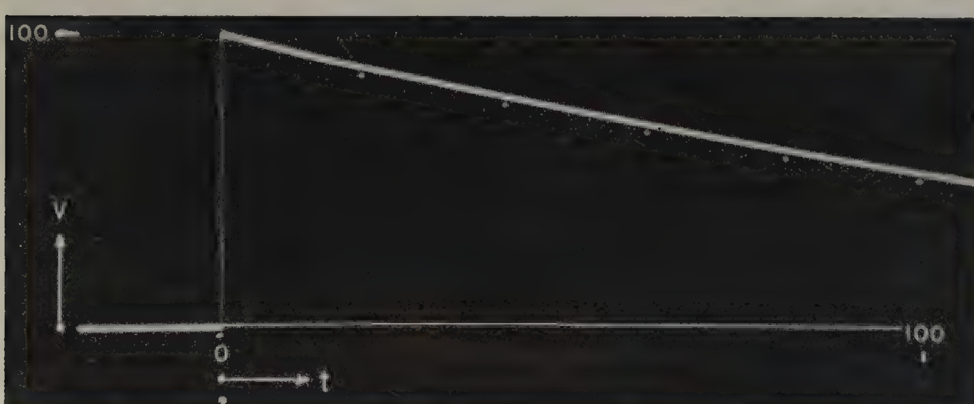


Fig. 7. Full wave (0.05×100 microseconds) applied to long-time scale model of 30,000-kva transformer. Time markers 20 microseconds apart

oscillation of the winding (21 kc) is evident in Fig. 5. Even more clear, in Fig. 6 is the startling traveling-wave propagation of the gradients along the winding, the reflection from the grounded neutral end at about 25 microseconds, and the minor reflection at about 14 microseconds caused by the discontinuity of the break and taps at the center of the winding. These two last pictures required about 10 seconds exposure each, to allow the scanning of the entire winding, and each contains 35 oscillograms.

As explained previously, with the long-time scale analyzer it is possible to obtain simultaneous voltage distributions, that is, voltage distributions along the winding at a predetermined fixed time. The "initial" distribution shown on Fig. 4 was taken at a very short time (0.04 microsecond) and practically is coincident with the electrostatic distribution, which theoretically is established immediately in a transformer upon application of a unit function voltage.[3]

It is interesting to note that the total time required to photograph all six frames was less than one hour, including the adjustments of the applied waves, sweeps, scanning mechanism, etc. These six pictures contain the equivalent of about 100 readings from oscillograms, and about 70 waveshape tracings, all arranged in the most useful form to the designer. The time required to obtain the same amount of information from the original transformer may be estimated at 10 hours.

It must be emphasized that Figs. 2 to 7 represent information on transient voltages in this particular transformer, only for one applied wave (0.05×100 microseconds) and only for one set of winding connections and terminations of the nonimpulsed windings. The time and labor required for a thorough study, encompassing variations in the applied waves and a multitude of connections and terminations, would be almost prohibitive if the tests had to be done on the transformer itself. Furthermore such large units are available in the factory for these special tests only for a short time, since they must be shipped to the customer as soon as possible. With the long-time scale model of the 30,000-kva transformer studies were made of the effect on the various voltages and gradients of varying the length of the front and of the tail of the applied wave as previously described, of varying the time and the steepness of the chop, of changing the winding connections from Y-Y to delta-Y and to Y-delta, of grounding and isolating the neutrals, of changing the terminations of the nonimpulsed high- and low-voltage windings, etc. It may be concluded that the long-time scale model is particularly advantageous for detailed and thorough studies which require measurements at a large number of points, with a variety of applied waves, winding terminations, and connections.

APPLICATIONS OF ELECTROMAGNETIC MODELS

Since the feasibility, the accuracy, and the usefulness of electromagnetic models have been demonstrated, many models have been and are being built for various applications. The most important applications are, of course, in transformer design and development. Improvement can be made in the present designs in order to establish uniform safety factors. New structures and winding arrangements can be developed and modified readily to obtain the best solution for the many and varied characteristics of a modern transformer. Models also may be very useful to determine, in special cases, which winding structure is best suited to meet the customer's specifications.

Fig. 8. Full-wave voltages to ground at mid-point of high-voltage impulsed winding of 30,000-kva transformer and its model of time scale 35:1

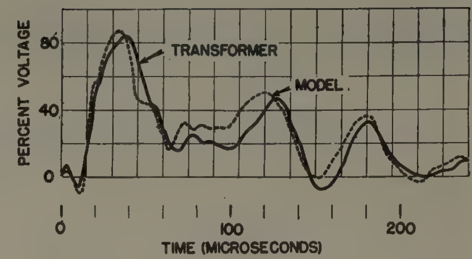
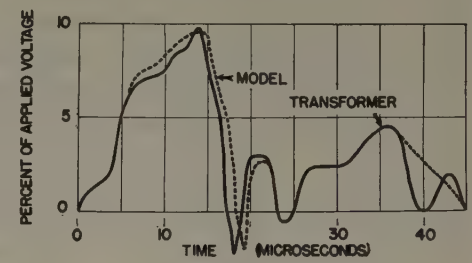


Fig. 9. Full-wave voltages across 2.5-per-cent tap section in impulsed high-voltage winding of 30,000-kva transformer and of its model of time scale 35:1



The reproduction of the transformer internal characteristics is the most interesting property of the electromagnetic model, and the most useful for design and development. However, a correct model reproduces not only the internal characteristics of a transformer but also its performance as a component of a power system. It follows that many external effects of a transformer may be predicted by means of models. An important application is the study of transfer of lightning surges through transformers, of the stresses to the other apparatus connected to the transformers, and of the required protective measures. As an example, a model was built to study the surge transfer in a 3-winding transformer rated 30,000 kva, 110 kv, to 66 kv to 24 kv. Since only the terminal voltages of the transformer were of interest, rather than the internal voltages, it was convenient to design the model with less detail, with scale of lengths of 1/15, thereby saving weight and cost with respect to other more complicated models. Models also have been used to study the effect of transformers on switching surges in extra-high-voltage stations,[4] on circuit breaker recovery voltages, etc. The summary of possible applications which have been given here is by no means complete. New applications undoubtedly will be found for this new tool, and the electromagnetic model technique probably will be extended to study the internal voltages in other electromagnetic apparatus, for instance air- and iron-core reactors and rotating machines.

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General Problems Related to the Temperature Classification of Insulating Materials

H. F. MILLER

With the large number of synthetic high polymers developed in the past 10 years by the chemical and electrical industries, a new test code, for trial use, was necessary and has been issued. Two approaches are recognized: one is a functional test on an insulating material and the other is a test on a complete insulating system. The necessity for test data is stressed.

THE USE of insulating materials in electric machines and apparatus has been guided for many years by the principles laid down in AIEE Standard No. *1*.[1] In this standard, specific insulation classes are defined in broad chemical terms, and definite limiting temperatures are set for their use. For some time, it has been recognized that these somewhat rigid rules no longer meet the needs of the electrical industry. A new edition therefore, has been in preparation for some time, and will come out in the very near future. The familiar *A*-, *B*-, and *H*-insulation classes are retained in this new edition of AIEE No. *1*, but their familiar definitions are extended to include materials and insulation systems that meet the requirement of specific AIEE functional test codes. The first of these new test codes, AIEE No. *1C*,[2] has been issued for trial use, inaugurating this new method of defining electrical insulation.

All this has come about because of the greatly accelerated development of synthetic high polymers in the last 10 years by the chemical and electrical industries. New materials, such as the silicones, fluorocarbons, polyesters, improved phenolics and alkyds, several types of thermoplastics, and many others are now available, with every indication that this outpouring of new materials from the chemical industry is only in its early stages.

Many of these materials have interesting properties, such as increased temperature resistance and better resistance to oxidation, and as such, are finding important applications in electric apparatus; however, the problem of determining which of these materials are useful, and where, is becoming a rather formidable one.

The composition of some of these new materials is such that classification by the presently used chemical definitions is particularly inadequate. Furthermore, a better understanding of the effect of the environment on the life of insulating systems is being gained, including in environment such things as humidity, vibration expansion and contraction, atmosphere, as well as temperature. True enough, we need more quantitative data than we now have.

Past workers in AIEE have developed the "degree rule" as a guide to insulation life, in which an increase of 8–12 C means a decrease of one half in insulation life. Further work has shown that this ties in closely with chemical reaction-rate theory, in which a straight line is produced when the logarithm of a specific reaction rate is plotted against the reciprocal of the absolute temperature. Temperature is the only known environmental factor which relates to insulation life in such a fashion. Temperature, therefore, must be the foundation stone in any new classification structure which is devised.

In regard to the various approaches to temperature classification, for one thing, the very real and tangible benefits that can flow from such work should be stressed. First, more efficient use of materials can be made. Certain organic insulations will be used to the limit of their capabilities, rather than being limited, for example, to class *A* 105 C hot-spot temperatures.

EQUIPMENT PERFORMANCE ASSURED

UNDOUBTEDLY the major benefit to be obtained from an improved temperature-classification system is the increased assurance of equipment performance that would result from more quantitative and meaningful data. This is important to the user of electric equipment but it would be doubly useful to the laboratory development people and the design engineers who wish to make insulation advances. Too often in the past, the engineer has held his nose, so to speak, when confronted by the laboratory evaluation of the capabilities of a new material and the laboratory development man has done likewise when judging the approach exercised by the engineer in using a new product. Even today claims are being put forward concerning the temperature stability of some new materials that undoubtedly will not stand up as more functional test data are accumulated. By cutting down the area where judgment is required, a related benefit will be obtained in that time will be saved in putting to work, in new designs, the advances that are being made in insulating materials.

If these desirable benefits are to be obtained, there is a need for not only interest in the industry but also for much hard work. It is agreed rather generally in the United States that temperature limits for insulating materials should be determined by test; however, a great variety of opinion exists as to what tests are under discussion. This is a healthy situation as long as the industry tries a variety of test approaches, accumulates a respectable body of data on the behavior of insulation in a variety of environ-

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ments, and relates this information carefully with the large body of accumulated experience on the behavior of present insulations in present equipment.

TWO TYPES OF TESTS

So far two methods of approach are generally recognized. One consists of a functional test on an insulating material or combination of materials. The other is a test on a complete insulating system, either in apparatus or in models. Both of these approaches should prove to be useful and important, and industry activity is needed to delineate the proper sphere of usefulness for each of them. This means the accumulation of sufficient data so that sound test methods can be outlined.

The logical outcome of such activity is the development of sound scientific classification systems. The question, therefore, should be asked as to what the effect of adequate temperature classification might be on design and equipment standards. It could be expected that initially tests will be used to compare new materials or apparatus designs with older materials or apparatus. In this way "bench marks" will be developed. Many viewpoints exist as to where to go from there. If a few opinions were to be offered, the first would be that in the long run, on small devices, the insulation system test and the functional test may prove to be one and the same thing. As far as standards go for this class of apparatus, it is possible that the conventional temperature classes could disappear and apparatus would be rated as to its life at various temperatures.

In some of the larger apparatus it may be possible to develop a simulated insulation system for test, but in many cases this will not be practicable and functional tests on insulating material must be depended on. Here it is probable that a variety of functional tests will be developed for each type of insulating material since an insulation will be subjected to a different environment in each type of apparatus in which it is used. It would be shortsighted, for instance, not to use a product in a static device just because it was not tough enough for rotating machinery.

Temperature classes for large equipment may be retained and new ones added, where justified, but the materials to be used in each class, it is hoped, will be justified by test rather than by the present material definitions.

It is, of course, possible that time may prove that the best practice for some parts of the industry would be to have equipment designed with standardized mounting dimensions to meet only performance requirements, such as horsepower, starting torque, breakdown torque, short-time overload ratings, regulation, power factor. Temperature of various component parts would be determined and the materials most applicable for these parts would be used. Perhaps certification of operating temperatures for different parts will be made, with proof by certified test that the insulating materials are capable of operation at the stated temperatures.

WHAT WILL THE USER GET?

In all this talk of higher-temperature materials something should be said about what the user will or will not get for his money. There is no particular virtue, *per se*, in assuming that all types of apparatus ought to operate at high temperature just because the materials might be available to allow construction of such apparatus.

In many cases, of course, a high ambient temperature is dictated by the surrounding environment or by the necessity to keep weight at a minimum. However, the reverse is also true, for in some apparatus environmental factors such as moisture, contamination, or vibration call for lower operating temperatures. In such apparatus, as motors and transformers, the move to higher operating temperatures should be made only if there is an over-all economic benefit in doing so. This over-all economic benefit must be a factor in not only initial investment but also total operating costs during the life of the equipment.

For each type of apparatus, analysis will indicate that there is an optimum temperature above which the user will lose out in higher operating costs, because of inefficiencies contributed by such things as higher copper-winding losses, and by less stand-by and overload capacity than the user must have, because of much higher hot-spot temperatures than those to which he is accustomed in present-day equipment. What this optimum temperature will prove to be in each case must be determined, then, not only by the technical factors but by the economic ones as well.

One certainly should not minimize the problems involved in developing a worth-while temperature classification system. There is the problem of accurately identifying materials because of varying formulation practices among vendors. Another corollary problem arises from differences in stability among products in the same class of materials. The need for statistical test data can make testing programs quite burdensome, even if the experiments are planned quite carefully.

UNDERSTANDING NEEDED

These are all technical problems, however, and as such, are capable of solution. Perhaps the major problem is that of skepticism, first on the part of the designer or user who today does not believe that laboratory tests can be significant, and, second, on the part of the laboratory man who does not understand the practical problems faced by the designer.

Everyone wants progress. There is pressure for it, not only because the possibility of effectively using new materials to advantage is realized, but also because no valid reason exists why enthusiastic co-operation between the designer and the laboratory man will not reach a solid understanding as to the test methods needed and the objectives to be reached.

Both technical advances and economic benefits can result from the more intelligent application of new insulating materials. To realize these, persistent effort is needed throughout the industry in developing functional material tests and systems tests that will tell what is needed to know to design and use the improved apparatus of the future.

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The Bewildering Decibel

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FELLOW AIEE

The term "decibel" has been used for quantities for which it is not the assigned designation. Confusion and error have resulted. To restore precision and stability to our technical terminology, it is recommended that this term be assigned specifically to unit transmission loss and that the word "logit" be used for standard magnitudes which combine by multiplication. Thus logit would serve as a companion to the word "unit" now used for standard magnitudes which combine by addition.

THOSE charged with the maintenance of our technical terminology report difficulty with the decibel. There is division, they tell us, between those who would "liberalize" its definition and those who would "circumscribe" it. Whenever the adequacy of any technical definition is questioned it should be reviewed critically.

The word "decibel," like any other word, may be described as a code for a concept. As our knowledge advances to the comprehension of a new concept specifications for it are formulated and some word assigned as its designation. The definitions appearing in dictionaries are, in reality, carefully drafted specifications for the concepts for which the associated words are the accepted designations. The dictionary itself describes its definitions as statements of the fixed limits, or of the precise boundaries, of the things defined.

There have been repeated proposals that the boundaries defining the decibel be extended. The declared objective is to make its advantages available when dealing with quantities not now included within these boundaries. In any expanding technology it is, of course, both necessary and desirable that adequate provision be made for dealing with newly introduced quantities and for the effective manipulation of relations between quantities. It would appear, therefore, that the first step in an attempt to resolve the difficulty of the decibel is to determine what it now does and what it fails to do that should be done.

WHAT IS A DECIBEL?

THE most authoritative statement of what is meant by the word "decibel" is that to be found in the "American Standard Definitions of Electrical Terms." The definition there given, as approved by the AIEE, the Institute of Radio Engineers, and other professional groups, describes the decibel as one-tenth of the fundamental division of a logarithmic scale for expressing the ratio of two amounts of power. The "American Standard Acoustical Terminology," sponsored by the Acoustical Society of America and the Institute of Radio Engineers, describes the decibel as a "dimensionless unit" for expressing the ratio of two values of power. We conclude, then, that the decibel is a standard reference quantity for measuring relative power.

One widely used dictionary says that the decibel is a unit of power ratio; another says that it is a measure of the loudness of sound. Acoustical engineers commonly express the magnitude of changes in acoustic pressure in decibels. They also use it as though it were a unit for expressing absolute magnitudes of acoustic pressure, although such usage is contrary to the recommendations of their published standards. Proposals have been made to use the decibel for evaluating relative frequency, for evaluating statistical variance, and for other relative magnitudes.

At this point it will be helpful to recognize an important principle which has been stated by Dr. Percy Bridgman. This reads: "For of course the true meaning of a word is to be found by observing what a man does with it, not what he says about it." Let us therefore, see what men do with the decibel.

In 1924 R. V. L. Hartley[1] described a standard reference quantity which he called a "transmission unit." He discussed its nature, its size, and its purpose. At about the same time papers by W. H. Martin[2] and by C. W. Smith[3] discussed the use of this quantity in connection with telephone transmission reference systems and for measurements of telephone transmission in general. In 1929 Martin[4] published a short paper announcing that, as the result of actions by the International Advisory Committee on Long Distance Telephony in Europe, the quantity previously known as "the transmission unit" would be designated thereafter as the "decibel."

During the past quarter century the concept of transmission loss has become essential to the work of communication engineers and of many others. The quantity which has been generally used as the standard reference transmission loss is the unit transmission loss described by Hartley. Since 1929 its only designation has been the word "decibel." In view of this it is surprising to find that the "American Standard Definitions of Electrical Terms" makes no mention of transmission loss under the definition of the decibel. Under the definition of transmission loss, on the other hand, is the statement, "Transmission loss is usually expressed in decibels." Formulas for computing the numbers of decibels equivalent to specific transmission losses are to be found throughout these official definitions. By observing what people do with the word "decibel" we find that it is used as the designation for a unit transmission loss.

The transmission losses of an energy transmission system may be measured, in some cases, by direct comparison with

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the known transmission losses of a calibrated system. In general they may be computed from measured impedances which, like the losses, are characteristic of the system. Any transmission loss thus evaluated is uniquely identified with a corresponding power ratio, or relative power. This method of evaluating relative power has been found so convenient that it is now used more generally than any other. It is not to be wondered at, therefore, that the constant measurement of relative power in terms of transmission loss has led, by metonymy, to the gradual use of the word "decibel" as the designation for a standard power ratio as well as for a unit transmission loss.

The decibel, as already noted, has entered into alliances other than those with transmission loss and relative power. It is often found in the role of a measure of relative electric voltage, of relative electric current, and of relative acoustic pressure. When permissible the evaluation of these quantities in terms of the decibel has been found to be accompanied by certain advantages. These have proved so attractive that a strong desire has been manifest to enjoy them in situations where the enabling conditions do not exist. It is here that things begin to get out of hand. Unfortunately warnings by technical committees have been so mild that they appear to condone, rather than to condemn, practices which lead to serious errors. In reporting this usage the "American Standard Definitions of Electrical Terms" says, "By extension, these (previously described) relations between numbers of decibels and ratios of currents and voltages are sometimes applied where these ratios are not the square roots of corresponding power ratios; to avoid confusion, such usage should be accompanied by a specific statement of this application." Confusion has not been avoided. Many have interpreted the statement quoted as an official release from rules set by fundamental relations between physical quantities. Restrictions which few overstep when dealing directly with such quantities are repeatedly disregarded when dealing with the logarithms of their ratios. The consequent errors, which are inevitable, are not committed solely by novices; nor are they trivial. Important documents which have been written and reviewed by men eminent in their profession have contained statements which are demonstrable contradictions of basic physical laws. Measurements of power magnitudes have been found to yield results which have differed by several orders of magnitude from estimates based on computation. These errors can be attributed directly to the practice of expressing current ratios, or acoustic pressure ratios, in decibels when these ratios are not the square roots of corresponding power ratios. When the cause of such an error is finally disclosed, the process which led to it is usually defended on the ground that it has official endorsement. Here is one place, certainly, where our present terminology needs overhaul.

From the foregoing a view is obtained not only of what people do, rightly or wrongly, with quantities which are said to be decibels, but also of what they would like to do. It is believed to be more worth while to provide adequate means to satisfy the needs thus indicated than to adjudicate any dispute as to the meaning of a word. Let us, therefore, set the word "decibel" to one side for the time being and examine, unhampered by prejudice, those quantities and concepts which it has brought to our attention.

TRANSMISSION LOSS

Transmission loss is a measurable property of energy transmission systems. As such it may be evaluated in the same manner as any other physical quantity, that is, as the ratio of its magnitude to the magnitude of a unit quantity of like kind. Those properties which a physical quantity shares with its unit, and which form the basis for a comparison of their magnitudes, are known as its dimensions. Dr. Ernst Weber[5] has described a dimension as follows:

> "Be it clearly understood that dimension is simply the expression of a general unit and therefore a characteristic peculiarity of physical quantities, not occurring in mathematics. There are as many dimensions, or general units, as there are kinds of physical quantities."

In speaking of the magnitude of a given transmission loss it is customary to say that the number of unit losses equivalent to the given loss is ten times the logarithm to the base ten of the ratio of two powers significantly associated with the given loss. This may be expressed symbolically as

$$N = 10 \log_{10} \frac{P_1}{P_2} \; UTL$$

where the symbol UTL represents the unit transmission loss. The appearance in this expression of a dimensionless ratio, and more particularly of the logarithm of such a ratio, has led many to the belief that the quantity here in question is dimensionless. This is not true. Every such expression for the magnitude of a physical quantity, as, for example, $S = 15\,yd$, contains the product of a pure numeric and a dimensional unit. The pure numeric is, in fact, the dimensionless ratio of the given quantity to the unit quantity. The formula for transmission loss contains a product of exactly this form. The expression $10 \log_{10} (P_1/P_2)$ gives the value of the numeric required in this case. This expression does not also lead to a dimensional equation, as expressions in similar positions sometimes do, giving the relation between the dimensions of the quantity computed and those of the quantities used in the computation. Such a dimensional equation does not exist here. This is not because transmission loss is dimensionless, however, but because its dimension is independent of the dimensions of power.

The situation which has just been described is not peculiar to transmission loss. The formula for a given temperature is

$$T = 273.18 \left(\frac{p}{p_o} - 1\right) \; {}^\circ\mathrm{C}$$

Here the numeric showing the ratio of the given temperature to unit change in temperature is expressed in terms of a dimensionless pressure ratio. This expression shows, not that temperature is dimensionless, but that its dimension is independent of the dimensions of pressure.

Transmission loss, like temperature, is a dimensional quantity. Its unit does not, it is true, belong to that large family of derived units each of which may be expressed in terms of the units of mass, length, and time. That it is not related to such units is not evidence that it is dimensionless, but that it is a fundamental dimension.

If the decibel is a unit transmission loss it is *not* a "dimensionless unit." The number one is the only dimensionless unit.

RELATIVE MAGNITUDES

With the exception of transmission loss, all of the quantities which have been associated with the word "decibel" are relative magnitudes. The relative magnitude of a given quantity is the ratio of the absolute magnitude of that quantity to the absolute magnitude of some other quantity of like kind. The absolute magnitude of a given quantity is here understood to be the ratio of the magnitude of that quantity to the magnitude of a known fixed quantity, or standard reference quantity, of like kind. The utility of the concept of relative magnitude is due in part to the possibility of knowing the value of the ratio of two absolute magnitudes without knowing the value of either alone.

The numerical value of the absolute magnitude of a given quantity may be written as

$$n = A/a$$

where A represents the magnitude and nature of the given quantity, and a represents the magnitude and nature of the standard reference quantity. Since the two quantities are alike in nature the symbol n represents simply the ratio of the magnitudes of the two quantities; it is, therefore, a pure numeric.

When the given quantity is expressed in the manner described in the preceding paragraph we write

$$A = na$$

From this it is evident that the numeric n is the number of standard reference quantities a the magnitudes of which must be added together to equal the magnitude of the given quantity A. Since the numerical value expressing the magnitude of the reference quantity is here combined by addition with identical numerical values each may be said to be a standard difference. In practice this standard difference is always one; it is for this reason that the reference quantities used for evaluating absolute magnitudes are called unit quantities. For this reason, also, the numerical value of the absolute magnitude of any given quantity A is always the value n of the ratio of the given quantity to a unit quantity of like kind.

Since a relative magnitude is the ratio of two absolute magnitudes it may be written as

$$R = \frac{A_2}{A_1} = \frac{n_2}{n_1}.$$

The quantity R, like the quantity n, is a pure numeric. The numerical value of this quantity, like the numerical value of an absolute magnitude, may be expressed as the number of unit differences which must be added together to equal the given value. The symbol R, like the symbol n, represents the number of unit differences which are to be thus added.

The numerical value of an absolute magnitude or of a relative magnitude may also be expressed as the number of identical numerical values which must be multiplied together to equal the given numerical value. A given relative magnitude may thus be written as

$$R = r^m$$

where m is the number of identical numerical values, r, which must be multiplied together to equal R, the given magnitude. All quantities in this expression are pure numerics. Since the numerical value of the reference quantity is here combined by multiplication with identical numerical values each may be said to be a standard ratio. This standard ratio is never one, since the multiplication of a finite number by one results in no change in value. When the standard ratio is given a specified constant value other than one a given relative magnitude may be evaluated either as m, the equivalent number of standard ratios, or as R, the equivalent number of standard differences.

A scale of numerical values may be formed by laying off, along a straight line, a succession of equal intervals each representing a unit difference. On this scale the value of any given interval is the sum of the values of any intervals into which it may be subdivided. The origin of this scale is marked with the number zero since this is the number which, on this scale, indicates that no interval representing a change in value has been laid off. Such a scale, which constitutes a linear number scale, will be here designated as a difference scale.

A scale of numerical values may also be formed by laying off a succession of equal intervals each representing a standard ratio of specified value. On this scale the value of any given interval is the product of the values of any intervals into which it may be subdivided. The origin of this scale is marked with the number one since this is the number which, on this scale, indicates that no interval representing a change in value has been laid off. A scale formed in this manner and having the properties described will be designated as a ratio scale. There is no unit interval on a ratio scale, just as there is no zero interval on a difference scale.

A ratio scale may be formed on which the equal intervals representing a standard ratio having the value $10^{0.1}$ are of the same length as the equal intervals representing a unit difference on a difference scale. It will then be found that a denary interval on the ratio scale occupies the same length as a decade interval on the difference scale. If these two scales are laid side by side so that their origins coincide any point will represent a pair of values. If the value of such a point as given by the ratio scale is expressed as a power of 10, and the value of the same point as given by the difference scale as a multiple of 10, it will be found that the exponent required for one and the coefficient required for the other are the same number. On the dual scale thus formed an interval on the ratio side may be used to represent the ratio value R of a given relative magnitude. The coincident interval on the difference side then will represent the number m of standard ratios having the

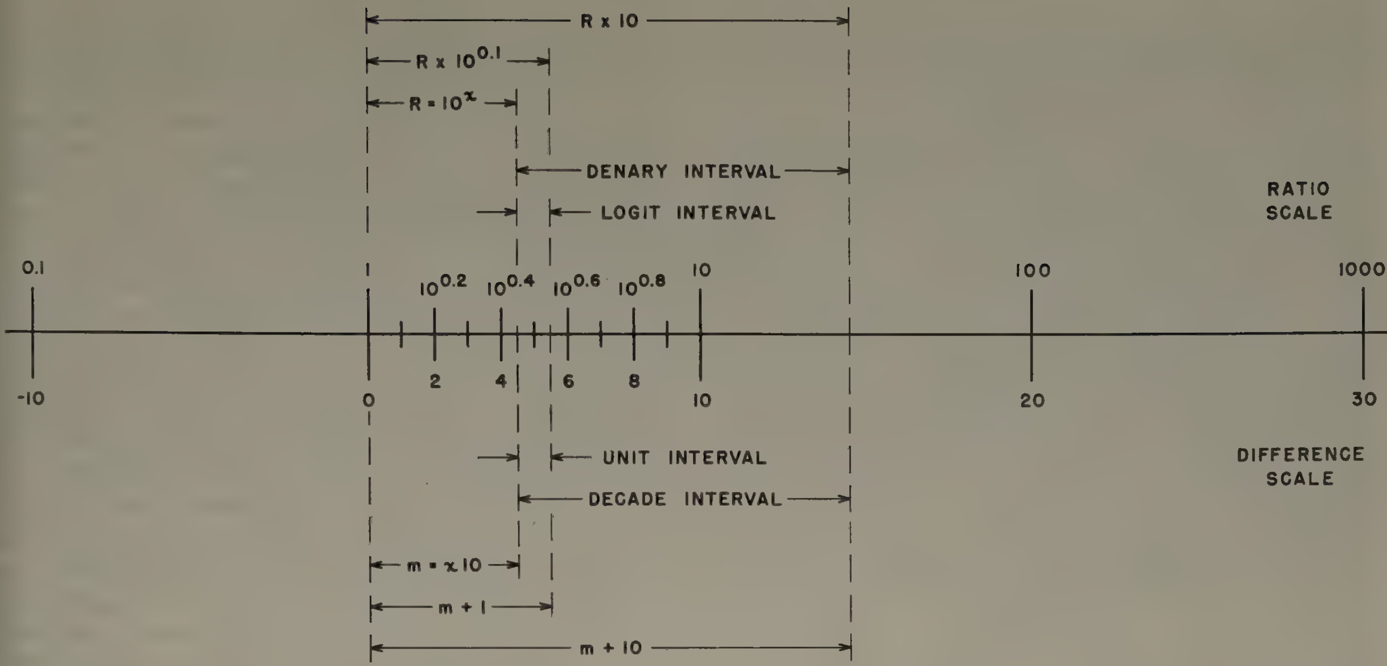

Fig. 1. Ratio and difference scales: Equal intervals on the ratio scale represent equal ratios; equal intervals on the difference scale represent equal differences. The value of any given interval on the ratio scale is the product of the values of its component intervals; the value of any given interval on the difference scale is the sum of the values of its component intervals. The value here specified for a standard ratio is $10^{0.1}$; the value of the coincident standard difference is one

specified value $r = 10^{0.1}$ which are equivalent to this relative magnitude. These relations are shown in Fig. 1.

Although these two scales have been described without reference to logarithms it is well known that the ratio scale is, in fact, a logarithmic scale of numbers and that the difference scale is a linear scale of the logarithms of these numbers. Either of these scales may be generated from the other by means of logarithms to the base r. The relation between the ratio value R of a given relative magnitude and the number m of standard ratios r equivalent to this given ratio may be written either as

$$R = r^m$$

or as

$$m = \log_r R$$

When the constant appearing in these equations is $r = 10^{0.1}$ the second of these two equations becomes

$$m = \log_{(10^{0.1})} R = 10 \log_{10} R$$

The quantity for which a designation is sought is the number $10^{0.1}$. This number is *not* a logarithm; it may be considered either as the base of a system of logarithms or as a standard elementary ratio. The advantages inherent in its magnitude, consequent on its relation to the decimal system, may be realized regardless of which point of view is taken. There are, however, advantages to the concept of a standard ratio which are not shared by the concept of a logarithmic base.

When the ratio of two quantities of like kind is expressed simply as a logarithm, the resultant is a pure numeric and nothing more. In general we have lost information, usually irrelevant, as to the size of the dimensional unit in terms of which the two quantities were measured. We have also lost information as to the nature of these quantities. This qualitative information is by no means irrelevant. Its loss may be avoided by employing the standard ratio described above as a standard relative magnitude. The equal values of a number of standard relative magnitudes, like the equal values of standard ratios, are to be combined by multiplication. Any relative magnitude may be expressed, by this process, in terms of an equivalent number of standard relative magnitudes.

To demonstrate this process the symbol $/P/$ will be used for a relative power when expressed as an equivalent number of standard power ratios having the value $10^{0.1}$. The symbol *SRP* will be used for this standard relative power. The operator *lgt* will be used to specify the process of taking logarithms to the base $10^{0.1}$, or, what is the same thing, of taking ten times logarithms to the base ten. We then have

$$/P/ = lgt(P_1/P_2)\ SRP$$

In this expression the right-hand side contains the product of a pure numeric and of a term which carries the essential information as to the nature of the quantities which it is the purpose of the expression to evaluate. This second term also carries information, likewise essential, as to the magnitude of the reference standard by means of which this evaluation is effected. The term, in other words, bears a functional resemblance to a dimensional unit. The entire expression, in fact, resembles those used with absolute magnitudes. It must be noted, however, that when this form of expression is employed a distinctive symbol, represented here by $/P/$, is required to indicate, first, that a relative magnitude is being evaluated, and second, that this relative magnitude is evaluated as an equivalent number of standard ratios and not as its own ratio value.

The standard ratio just described has the appearance, and certain of the properties, of a dimensional unit. The numerical value of this ratio, however, can never be one; there is no unit interval on the ratio scale. Intervals on the ratio scale representing standard ratios coincide with unit intervals on the adjoining difference scale; these unit intervals may be used for counting corresponding standard intervals on the ratio scale. The numerical values of all ratios are, however, given only by the ratio scale. When expressed in terms of a standard ratio the value of a given magnitude is a power of the value of this standard ratio; when expressed in terms of a unit the value of a given magnitude is a multiple of the value of this standard difference. The values of standard ratios are never unit values, nor do they combine as unit values combine.

If the decibel is a standard relative magnitude, whether of power or of any other quantity, it is *not* a unit.

THE LOGIT

It is believed that some of the difficulty which has been attributed to the decibel is due to our failure to recognize the elementary standard ratio, $10^{0.1}$, as a fundamental quantity and to provide it with its own distinctive designation. This quantity is as basic an element of a ratio scale as the unit quantity is of a difference scale. On comparing the ratio and difference scales described earlier it is found that for each of the characteristic intervals on one there is a corresponding characteristic interval on the other. A unit ratio corresponds to zero difference; a ratio of ten corresponds to a difference of ten; the ratio corresponding to unit difference has the value $10^{0.1}$. This ratio has been in use for many years. Its true identity as a fundamental quantity has been obscured, however, by our habit of saying that we were using ten times logarithms to the base ten instead of saying that we were using logarithms to the base $10^{0.1}$. The fundamental relations have been further confused by describing the decibel as one-tenth of a bel when the truth is that its value is the tenth root of the value of the bel.

An appropriate name for the elementary ratio might well resemble the word "unit" sufficiently to remind us of the similarities between standard ratios and standard differences. At the same time the two words might well differ in such fashion as to warn us of the differences in the behavior of these quantities. The word "logit," formed on the Greek root "*lógos*," meaning ratio, has been proposed[6] for this purpose.

A logit may be defined as a standard ratio which has the numerical value $10^{0.1}$ and which combines by multiplication with similar ratios of the same value. Logits may be used for evaluating absolute or relative magnitudes, the number of logits having a combined value equal to the numerical value of a given magnitude being the exponent indicating the power of the number $10^{0.1}$ which has that value. The *number of logits* equivalent to a given magnitude is the logarithm to the base $10^{0.1}$ of the numerical value of this given magnitude; the *value of the logit* is the value of this base. The logit is a number—not the logarithm of a number. The value of the logit and the values of given magnitudes which may be expressed in logits are represented by intervals on a number scale on which equal intervals represent equal ratios; the numbers of logits equivalent to the given magnitudes are represented by intervals on a related number scale on which equal intervals represent equal differences. Logits, like units, may be used for expressing relations between abstract quantities or, when suitably qualified, for expressing relations between physical quantities. The logit and the unit are similarly related to the decimal system: ten of each combine in accordance with the laws governing their combination, to give a resultant having a numerical value of ten. Semantically the words "logit" and "unit" are of the same order of abstraction.

The term logit may be qualified by using the designation of the appropriate generalized dimension as an adjective. It is neither necessary nor desirable to use the designation of a specific dimensional unit. One should speak, for example, of a "mass logit" rather than of a "gram logit."

Equations resembling those of dimensional analysis may be written for logits as well as for units. For example, if the intensity of radiant energy obeys the inverse square law one may say that it decreases at the constant rate of two intensity logits per distance logit. Logits and units may be combined in a single expression; an exponentially decaying voltage may be said to decrease at a constant rate measured in voltage logits per unit time.

A more detailed discussion of the use of logits for evaluating both absolute and relative magnitudes is given in the discussion of relative magnitudes[6] mentioned earlier.

WHAT SHALL BE DONE WITH THE DECIBEL?

We now recall the word "decibel" to inquire what part it may best play in the situation we find confronting us. The quantities which must be considered divide, as has been seen, between a standard transmission loss, which is a dimensional unit, and standard relative magnitudes which, if dimensional, are not dimensional in the usual sense, and which are not units.

If one is to deal effectively with relative magnitudes by the aid of these standard magnitudes an individual standard will be required for each kind of physical quantity and for abstract quantities. The word "decibel" could be used, of course, as the general designation for standard relative magnitudes. This, however, would constitute a complete reassignment of the word as the designation for a specified quantity. Having been for many years the designation for one quantity, although whether this quantity is transmission loss or relative power is uncertain, it would become the designation for a class of quantities.

It does not require much imagination to foresee that such reassignment of a technical term is unlikely to be accomplished without cost. Books have already been written in which the word is used in accordance with its original assignment. These will remain in our libraries for many years. Their authors would have just cause for protest if a word which they had relied upon to make their thoughts understood were caused no longer to mean what it once had been declared to mean. The real victims, however, would be the readers. If the meaning of any word is not preserved during its transit from author to reader statements in which this word appears will cease to

be trustworthy. This is particularly true of a word purporting to designate some precisely specified quantity. Those permitting such spoilage would incur the reproaches of judges and of legislators as well as of those who look upon such words as part of their stock in trade.

The justification for proposals to reassign the word "decibel" is said to be the need to extend its usefulness. There can be little doubt that such reassignment would destroy any usefulness which this term may have, rather than create additional usefulness. It is believed, however, that the motive is more properly described as a desire to extend the use of standard relative magnitudes having the value $10^{0.1}$. While strong objection may be raised to methods which have been proposed for reaching this objective none can be raised against the objective itself. Since it is now known to be advantageous to express relative magnitudes in terms of standard ratios, facilities for doing so should be made available. Fortunately proper facilities may be provided for dealing in this manner with all physical quantities, and with abstract quantities as well, without sacrifice elsewhere. All that is required is a sufficiently comprehensive nomenclature. It is suggested that a system designed specifically for the work in hand is likely to prove more successful than one formed by altering an existing system. Each of the quantities brought within the scope of the expanded technique will need its own reference standard, just as each absolute magnitude requires its own unit. Each such reference standard will need its own unambiguous designation. These designations should form a unified nomenclature which is conveniently related to nomenclatures already in use. It is believed that the adoption of the word "logit," as a companion to the word "unit," will provide the foundation for a nomenclature which meets these requirements simply, conveniently, and reliably.

If a coherent system of designations is postulated, applicable to relative magnitudes of all physical quantities, the standard relative power is best designated by that term which conforms to the general rules governing such a system. This leaves the term "decibel" free to serve as the unique designation for the unit transmission loss. Transmission loss cannot be logically incorporated into a nomenclature designed for relative magnitudes because it differs with respect to its dimensional character from such magnitudes. This must not be allowed to deprive the unit transmission loss of a reliable designation. Whatever else is done this quantity, which now supports many well-established techniques, must be provided with an adequate designation.

An attempt has been made in the foregoing paragraphs to establish the true character of certain quantities, the laws governing their behavior, and the relations between them. On the basis of the facts thus disclosed a proposal has been made regarding the designations by which these quantities may be identified. These designations have a form similar to, but not conflicting with, that of designations with which we have had a long and satisfactory acquaintance. The relations between quantities designated in accordance with the proposed system may be treated symbolically by processes which are logically related to those in which we are already proficient. The proposed system is coherent within itself and consistent with its environment. It is hoped that it may be helpful in restoring to our technical terminology some of the precision and reliability which appears now to be lacking.

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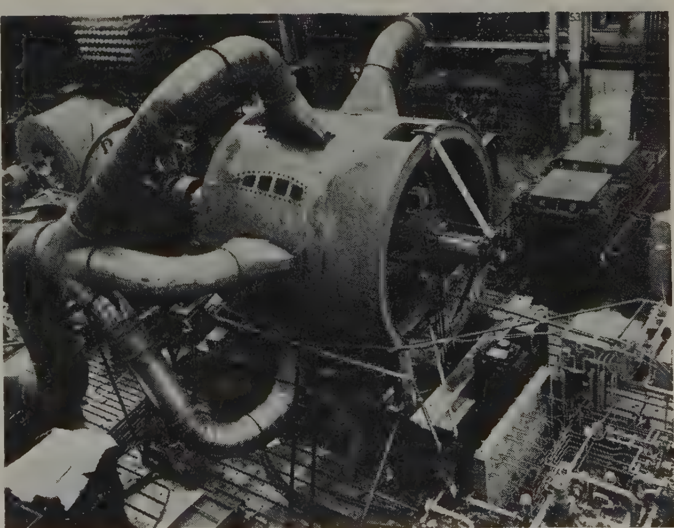
5. Handbook of Engineering Fundamentals, **O.W. Esbach.** John Wiley and Sons, Inc., New York, N. Y., 1952, p. 303.

6. Fundamental Considerations Regarding the Use of Relative Magnitudes, **J. W. Horton.** *Proceedings*, Institute of Radio Engineers, New York, N. Y., vol. 40, no. 4, April 1952, pp. 440–4.

Wind-Tunnel Drive Motor Undergoes Tests

Looking much like a "giant bug" ready to pounce, the 20,000-hp wind-tunnel drive motor shown at right is undergoing tests in the Westinghouse East Pittsburgh plant. The startling appearance is caused by six huge temporary ventilating air ducts fanning out from its frame. The motor is one of two identical 600-rpm synchronous motors that will power the modified Southern California Co-operative Wind Tunnel, Pasadena. The existing 12,000-hp subsonic tunnel is being converted to a variable-pressure transonic tunnel. It will operate at speeds from Mach 0.7 to Mach 1.3 at pressures ranging from 1/10 to 4 atmospheres. Each motor will have two fans, one mounted at each end of its rotor shaft. The motors will be mounted in tandem but will have no physical connection. Each motor will be supported by 12 aerodynamically shaped radial struts that also act as stationary blades for the fans. These struts also will carry cooling air, electric cables, and lubricating oil into the motors. The motors will be started by utilizing the wound-rotor drive elements taken from the existing subsonic tunnel as an induction-frequency converter. The tunnel is scheduled for completion early in 1955



Tentative Technical Program Announced for Summer and Pacific General Meeting

The AIEE Los Angeles Section as host for the Summer and Pacific General Meeting to be held June 21–25, 1954, in Los Angeles, Calif., extends an invitation to members of the Institute and their families to meet at the Biltmore Hotel and participate in an interesting program of technical sessions, inspection trips, and social events. It is suggested that visitors combine the convention with their summer holiday since Los Angeles offers unparalleled facilities and weather for the vacationer. Swimming and surf riding at ocean beaches, water skiing or swimming at mountain lakes, deep sea fishing, horseback riding on the many miles of riding trails, golf at a number of courses, and tennis are all available within easy driving distance of the hotel.

Inspection trips to industrial plants, steam-electric generating stations, communication facilities, aircraft manufacturing plants, and modern computer installations will supplement the program of technical papers.

Early arrivals will be welcomed Sunday afternoon at an informal tea in the Biltmore Hotel. This social gathering will bring together old acquaintances for a leisurely meeting in a restful atmosphere.

GENERAL SESSION

The Summer and Pacific General Meeting will be opened formally by Bradley Cozzens, general chairman, at 10:00 a.m., Monday. He will present Mayor Norris A. Poulson of Los Angeles, who will welcome the visitors. President Robertson then will deliver the keynote speech and will preside. The results of the recent election of national officers will be announced and the new president presented.

Presentation of the 1953 Lamme Gold Medal to F. A. Cowan, assistant director of operations, long lines department, American Telephone and Telegraph Company, will be made by President Robertson at the same meeting. This medal has been awarded to Mr. Cowan "for his outstanding contributions to long-distance communication and the development of modulating and transmission measuring apparatus of original design and application."

LUNCHEONS

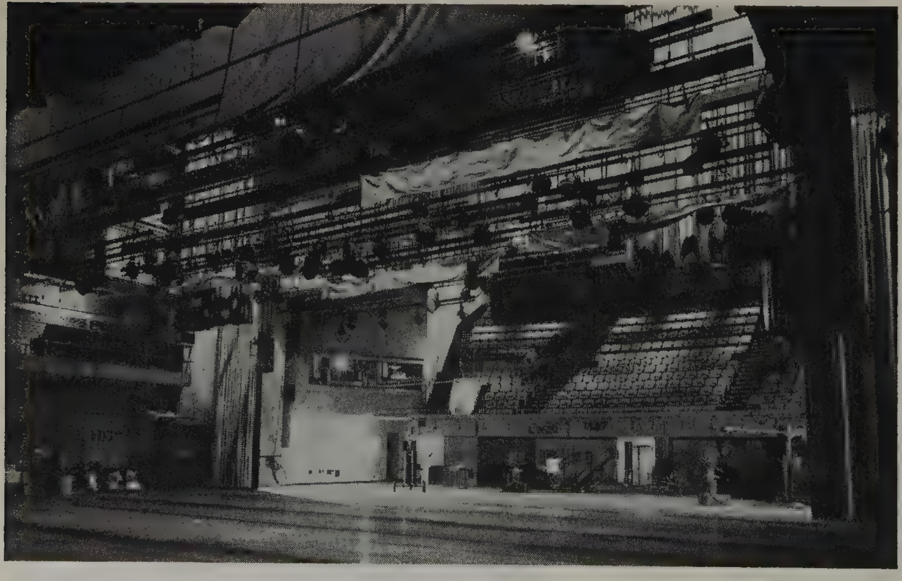
G. C. Tenney, Vice-President, District 8, will speak at the Monday luncheon. With the Diamond Jubilee of Light as a theme, he will discuss the role of electricity in the industrial development of the West.

At the Tuesday luncheon meeting, Walker L. Cisler, president of the Detroit Edison Company, will speak on the subject, "A Realistic Approach to Atomic Power."

Dr. Lee A. Du Bridge, president, California Institute of Technology, will be the speaker at the Wednesday luncheon. He will discuss "What Are Universities for?" The prize winners of all ten District Branch Paper Competitions will be introduced at this luncheon.

On Thursday, Eta Kappa Nu members and all others who are interested will attend a luncheon at the Hotel Statler with Dr. Lee de Forest as principal speaker. Upsilon Chapter of the University of Southern California and Los Angeles Alumni Chapter are cosponsors of the meeting.

Tickets for the luncheons are $3.00 each.



Interior view of one of the two audience studios at the new National Broadcasting Company Burbank Television Studios, showing control booth at left of the seating area. These studios will be visited during the combined tour of television facilities on Monday

Future AIEE Meetings

Summer and Pacific General Meeting
Biltmore Hotel, Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—closed*)

Petroleum Technical Conference
Tulsa, Okla.
September 27–29, 1954
(*Final date for submitting papers—June 28*)

Middle Eastern District Meeting
Abraham Lincoln Hotel, Reading, Pa.
October 5–7, 1954
(*Final date for submitting papers—July 7*)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 11–15, 1954
(*Final date for submitting papers—June 14*)

Machine Tool Conference
Hotel Statler, Detroit, Mich.
October 25–27, 1954
(*Final date for submitting papers—June 25*)

Southern Textile Conference
Raleigh, N. C.
November 4–5, 1954
(*Final date for submitting papers—August 4*)

1955 Winter General Meeting
Hotel Statler, New York, N. Y.
January 31–February 4, 1955
(*Final date for submitting papers—October 20*)

PRESIDENT'S RECEPTION AND BANQUET

The President's Reception will be held on Thursday at 6:00 p.m., followed at 7 o'clock by the banquet. The golf prizes will be presented at this function and a group of entertainers will add to the festive spirit of the evening. Both of these affairs are informal; however, dress is optional. There will be no charge for the reception. The banquet and entertainment will be $10.00.

EVENING ENTERTAINMENT

Evening activities on Monday and Tuesday have been planned to combine technical interest with an evening's entertainment. A trip to the National Broadcasting Company and Columbia Broadcasting System television studios has been planned for Monday evening. In addition the equipment used by Pacific Telephone in supplying television circuits to the broadcasters will be demonstrated. (7:00 p.m., $1.00.)

Mount Wilson, with its array of television stations and the world-famous Observatory will be visited on Tuesday evening. This trip will be routed through suburban residential areas and will include a pleasant ride in the mountains over a high-gear highway. A box supper will be enjoyed at a location overlooking the entire valley, a mile below. (4:30 p.m., $4.00.)

On Wednesday evening, the years will be rolled back to the "Gold Rush Days" with a family-style dinner at Knott's Berry Farm.

Authentic ghost town attractions have been assembled here from all over the west, including a narrow gauge railroad in operation, stage coaches carrying passengers, a gold mine that can be entered, a stamp mill in operation with a sluice box where one may pan gold, a general merchandise store of the vintage of 100 years ago, as well as countless relics of the pioneer days of the West. Chicken dinner will be $2.50 (steak dinner at added cost); transportation is $2.50. The trip to the farm at Buena Park, 40 miles from Los Angeles, will afford a splendid opportunity to view the tremendous industrial development of the metropolitan area.

For those who do not desire to participate in these evening events, there will be information available at the Registration Desk on such alternative attractions as Olvera Street with its genuine Mexican atmosphere, the Plaza and old Los Angeles Mission, the Turnabout Theater with its famous puppet show, and a host of other attractions.

STUDENT ACTIVITIES

Competition for District 8 Student Papers will be held Monday afternoon, June 21, with prize awards at the Wednesday luncheon. The prize winners from the remaining nine Districts also will be introduced at the same luncheon.

The tour to California Institute of Technology should be of great interest to students, and trips will be arranged as the need is indicated.

Many papers to be presented at the various technical sessions will be of special interest to students and it is suggested that the program be studied for particular spheres of interest.

HOTEL RESERVATIONS

A large block of rooms has been reserved at the Biltmore Hotel, meeting headquarters with additional facilities available at other nearby hotels as follows:

Biltmore Hotel	
Single	$ 5.50 to $11.50
Double	8.50 to 14.00
Suites	18.00 to 33.00
Hotel Statler (five blocks from Biltmore)	
Single	$ 6.50 to $14.00
Double	9.00 to 16.00
Suites	19.00 to 34.00
Mayflower Hotel (across street from Biltmore)	
Single	$ 5.50 to $ 8.00
Double	5.50 to 9.00
Suites	14.00
Hotel Clark (two blocks from Biltmore)	
Single	$ 4.00 to $ 5.00
Double	5.50 to 7.50

As this is the tourist period in Los Angeles, it is suggested that hotel reservations be made as early as possible by returning the "Hotel Reservation Card" sent to all members. Confirmation of reservation will be sent by the hotels. *Do not send money to the committee.*

LADIES' ENTERTAINMENT

A committee of 100 ladies, with Mrs. Ernest K. Sadler as chairman and Mrs. Bradley Cozzens as vice-chairman, have arranged a program for the ladies which should make their visit to Los Angeles a most enjoyable one.

The Galeria Room of the Biltmore Hotel has been reserved for the exclusive use of the ladies from Monday through Thursday. A coffee hour will be held there each morning at 9:00 a.m. All the ladies are cordially invited to use these facilities at their pleasure.

A fashion tea has been planned for Monday at Bullock's Wilshire store at 3:00 p.m. Busses will leave the Biltmore Hotel from 1:30 to 2:30 p.m. and leave the store at 5:00 p.m. for the return trip, allowing plenty of time for shopping in this very beautiful and exclusive shopping district. Tickets will be $1.00.

On Tuesday there will be a tour through the orange grove country, to Padua Hills Restaurant, situated on an olive-clad hill at the base of the Sierra Madre Mountains. Here Mexican players will entertain with their Spanish songs and dances during the luncheon hour. Busses will leave the Biltmore Hotel at 10:00 and 11:00 a.m. The attendance at this event is limited to 200, so reservations should be made early. Tickets will be $3.75.

On Wednesday morning there will be a trip to Forest Lawn Memorial Park to view the famous "Last Supper" window and the painting of the "Crucifixion" by Jan Styka. Busses will leave the hotel at 9:15 a.m. and return at 12:00 noon. At 1:30 p.m. busses will leave the hotel for a tour of the Huntington Library and Art Gallery, which houses many treasures of art and literature, including the original "Blue Boy" by Gainsborough. Tickets are $1.00 for each trip.

Busses will leave the Biltmore at 10:00 a.m. on Thursday for a tour of Beverly Hills, movie stars' homes, the University of California at Los Angeles, and to the Pacific Ocean beach towns, arriving at 1:00 p.m. at the beautiful Wilshire Country Club for luncheon, followed by entertainment by Miss Lynn Blakeslee, concert violinist. The Luncheon Committee has arranged to have many lovely door prizes at this event. Tickets will be $4.50.

INSPECTION TRIPS

Kaiser Steel Corporation and Exchange Orange Products Company (Monday, June 21, 1:30 p.m., combined trip $2.50). Kaiser Steel Corporation, located at Fontana, Calif., adjacent to the city of San Bernardino, on a 1,300-acre site, is a fully integrated steel mill, the first of its type on the Pacific Coast. It is the only steel mill on the coast with its own coke oven and blast furnaces as well as open-hearth furnaces and steel-finishing facilities.

In addition to pig iron and coke oven by-products, it produces semifinished and finished steels: plate, large and small structural shapes; continuous weld pipe; hot- and cold-rolled strip, skelp, carbon and alloy bars; and foundry products. This mill produces pipe from 1/2 inch to 4 inches in diameter.

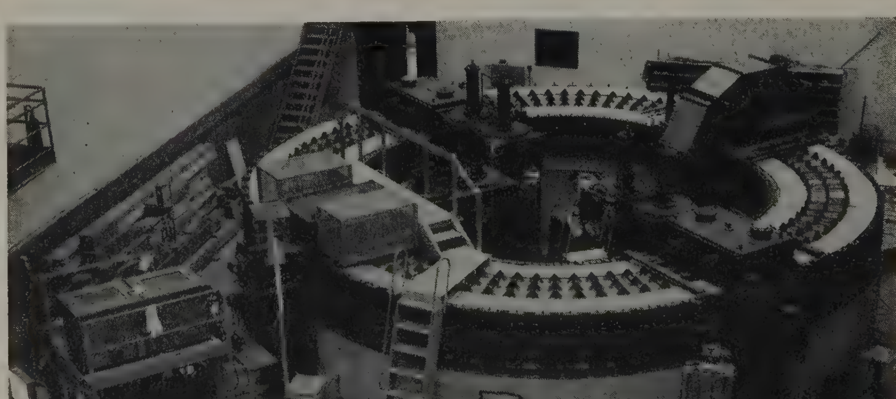
A complete tour of this plant by AIEE visitors should be one of the industrial highlights of the meeting.

Exchange Orange Products Company, located at Ontario, has a daily capacity of 1,400 tons of fruit. This plant produces orange juice in various forms, orange oil, citrus molasses, orange pulp, pectin, and other essential oils used in food, beverage, and pharmaceutical industries. Some 1,200,000 gallons of frozen concentrated orange juice were produced during 1953.

Operating at capacity, the plant in the inspection, washing, and processing of the fruit, will consume 3,000,000 gallons water, 2,700,000 pounds steam, 1,000 kwhr electric energy, 4,000,000 cubic feet natural gas, and 450 gallons fuel oil per day.

Pacific Telephone Grand Toll Building (Daily tours, no charge). Pacific Telephone is opening its Grand Toll Office for two conducted tours in small parties. Both tours can be completed in the same morning or afternoon. To be viewed during the first will be the latest facilities for transmission, monitoring, and control of intercity monochrome and color television images, audio programs, and telephone messages. Transcontinental microwave radio relay and *L-1* coaxial-cable carrier terminals will be featured.

The second tour will allow inspection of a recently completed $6.5 million toll dialing project. Aimed ultimately at nation-wide



The Synchrotron which accelerates electrons over a distance of 45,000 miles to a speed approaching that of light and imparts to the electron energy amounting to a billion electron-volts, will be seen during the inspection trip on Friday to the California Institute of Technology

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in Los Angeles, Calif., at 10:00 a.m., Monday, June 21, 1954, during the Summer and Pacific General Meeting.

At this meeting the annual report of the Board of Directors and the report of the Committee of Tellers on the ballots cast for the election of officers will be presented. The Lamme Medal will be presented to Frank A. Cowan (M '29, F '45).

Such other business, if any, as may properly come before the annual meeting may be considered.

Signed N. S. HIBSHMAN

Secretary

customer toll dialing, this system at present permits toll operators to complete connections rapidly by dialing directly to distant telephones in major cities throughout the United States. Dialing both to and from Southern California takes place in this manner. The *4A* Crossbar switching machine is the heart of the system.

These two tours will be daily, starting Monday afternoon, June 21, and running through Friday morning, June 25. Sixteen trips are scheduled. There will be no charge for these tours. The schedule is as follows:

	Mon	Tues	Wed	Thurs	Fri
9:00 a.m.		TV	TV	TV	TV
10:30 a.m.		4A	4A	4A	4A
1:30 p.m.	TV	TV	TV	TV	
3:00 p.m.	4A	4A	4A	4A	

Columbia Broadcasting System and National Broadcasting Company Studios and Pacific Telephone Television Center (Monday, June 21, 7:00 p.m., combined tour $1.00). The major television networks recently completed new West Coast studios featuring the latest developments in television program production. From these studios originate the transcontinental shows starring Hollywood motion-picture celebrities. A tour of CBS Television City and a tour of NBC Television Studios have been arranged. In both studios scenery, lighting, cameras, and control equipment will be on view. Methods of preparing scenery and stage "props" will be shown and operation of the control booth part of studio technical operation and production will be demonstrated.

Each of these tours is combined with a trip though Pacific Telephone's Hollywood Television Center where monitoring, testing, and amplifier equipment will be displayed. Mobile television trucks equipped with microwave radio system for remote pickup of television programs will be shown. This center is the Hollywood terminal for microwave systems carrying television programs to the Mount Wilson station for broadcasting. Operation of these systems will be demonstrated.

Etiwanda and Highgrove Steam Plants (Tuesday, June 22, 8:30 a.m., combined trip including luncheon at Mission Inn, Riverside $5.00). Etiwanda Steam Plant, placed in service in 1953 with two 125,000-kw generators, is the first inland steam station on the Southern California Edison Company's system, and delivers energy over two 220,000-volt lines into the transmission network at Highgrove and Barre Substations. The station is outdoor type of unit design with a centralized control room. Steam conditions at the turbines are 1,800 pounds per square inch, 1,000 F with reheat to 1,000 F. Cooling water is supplied from induced draft towers which are among the largest in the world. Auxiliary power is furnished by auxiliary generators driven from the main turbine shafts. Closed-circuit television is used in the control room to monitor boiler drum levels and furnace fires.

After this trip there will be luncheon at the famous Mission Inn in Riverside, which in turn will be followed by a visit to the Highgrove Steam-Electric Generating Plant of the California Electric Power Company.

Highgrove Steam Plant with a nominal rating of 100,000 kw, located at Highgrove between San Bernardino and Riverside, Calif., is one of the most completely outdoor steam-electric generating plants on the West Coast. All components with the exception of the operator's control and switchgear rooms are located in the open. The plant incorporates a number of unique design features. There are only two operating levels: at grade and at 14 feet. The result is easier and more economical operation and maintenance. The unusual construction increases earthquake resistance and enhances the appearance of the installation. When the fourth unit of this project is completed, production will be increased to 140,000 kw. Because of unit streamlined design, the plant is run with minimum operating personnel.

Richfield Oil Company (Tuesday, June 22, 1:30 p.m., $1.00). This plant, covering 560 acres, exemplifies the electrical development of a small into a large refinery, processing 115,000 barrels per day of crude oil into 50,000 barrels per day of gasoline plus other products. The growth represents an increase in load from about 1,500 kva to the present expected demand of 22,000 kva. It also represents a transition from a radial load to primary and secondary selective substations. The electric system also shows a transition from the open-type switchboard housed in a substation building to the outdoor, double bus, drawout-type switchgear. The entirely underground distribution system encompasses 30 substations, 10 switchrooms, 130 manholes, and uses lead cable or lead with neoprene covering. Connecting horsepower is 36,000, distribution voltages are 12 kv, 2.4 kv, and 460 volts.

Mount Wilson (Tuesday, June 22, 4:30 p.m., $4.00 including box supper). Located on famous Mount Wilson are seven vhf and two uhf television broadcast stations and the world-renowned astronomical observatory. Mount Wilson is over a mile high and visibility on clear days exceeds 150 miles. Inspection will be made of television transmitters, radio relay links, and The Pacific Telephone and Telegraph Company's terminal station for the Hollywood Mount Wilson Microwave Radio Relay System which transmits television programs from Hollywood studios to Mount Wilson for distribution to broadcast transmitters. A visit to the 100-inch telescope and to the Astrophysics Museum and other observatory facilities will be included. Work carried on at this observatory and some separate and interrelated activities at Palomar Observatory will be described.

Laguna Bell Substation (Wednesday, June 23, 9:00 a.m., $1.00). The world's first 220,000-volt installation was placed in service by the Southern California Edison Company, July 31, 1923, with two 60,000-kva 220/66-kv transformer banks and two 30,000-kva synchronous condensers. Two banks and two condensers have been added and 16-kv distribution capacity installed. Tremendous industrial load growth in the area served necessitated additional capacity. Existing transformers were replaced by four 220/66-kv transformer banks with modern load ratio control units having forced cooled rating of 480,000 kva, new 66-kv suspension busses providing greater damage resistance to seismic forces, new disconnecting switches, 66-kv oil circuit breakers, and a switchboard in an air-conditioned control house. The station is completely double bus on 220, 66, and 16 kv, providing maximum operating flexibility.

Lever Brothers Company (Wednesday, June 23, 9:00 a.m., $1.00). Opened in June 1951, the new Lever Brothers plant in Los Angeles is among the most modern plants of its type in the world. This $25,000,000 processing plant produces soap, detergent, and shortening for distribution over the entire western part of the country. The impressive group of reinforced-concrete and steel buildings occupies approximately one-third of a 30-acre tract adjoining the Santa Ana Freeway.

The center of the plant consists of a 4-story office and laboratory building flanked by a soap finishing and packing plant on the east and a shortening products finishing building on the west. Directly behind the main buildings are the processing facilities for the soap and edible oils.

Unique features of the plant include its 4,160-volt network distribution system and its outdoor construction. Taking advantage of the warm, dry California climate, much of the process equipment is located out-of-doors with shelters over the operating levels only.

Hoffman Television Corporation (Wednesday, June 23, 1:30 p.m., $1.00). More than 1,000 persons are employed regularly in this television-receiver manufacturing plant. Production entails arrival of components at the rear door and emergence of finished, packaged product at the front door. Production steps include riveting, subassembly of components, production-line assembly and wiring, testing, and final assembly. A total of 92 tests are given each television set before completion and there are extreme "drop tests" after completion. Picture and sound life tests are made up to 500-hour periods. Cabinets for the receivers are manufactured at another Hoffman Los Angeles factory.

Valley Steam Plant and Station "G" (Wednesday, June 23, 1:30 p.m., $1.00). The 512,500-kw inland Valley Steam Plant of the Los Angeles Department of Water and Power will be seen in all stages of construction on a 150-acre site in the San Fernando Valley.

(*Continued on page 562*)

Tentative Technical Program

Summer and Pacific General Meeting, Los Angeles, June 21–25

Monday, June 21

10:00 a.m. Opening Ceremony

Introduction of Pacific Coast Institute officers. Bradley Cozzens, general chairman

Address of Welcome. Mayor Norris A. Poulson

10:30 a.m. Annual Meeting

1. Report of the President. Elgin B. Robertson
2. Report of the Board of Directors. N. S. Hibshman, Secretary
3. Report of the Treasurer. W. J. Barrett
4. Report of Committee of Tellers on vote for nominees for AIEE offices
5. (*a*). Introduction of, and presentation of President's badge to A. C. Monteith
   (*b*). Response by Mr. Monteith
6. Presentation of Lamme Medal to F. A. Cowan, American Telephone and Telegraph Company, New York, N. Y.
   (*a*). The Establishment of the Medal. A. C. Monteith, Chairman, Lamme Medal Committee
   (*b*). The Career of the Medalist. J. J. Pilliod, American Telephone and Telegraph Company, New York, N. Y.
   (*c*). Presentation of the medal and certificate by President Elgin B. Robertson
   (*d*). Response by Mr. Cowan
7. Presentation of Honorary Membership Certificate to Dr. R. W. Sorensen
8. Any other business that may be presented

2:00 p.m. Color Television

CP.* Color Television Today. *D. E. Foster*, Hazeltine Research, Inc. of California

CP.* A Single-Tube Color Camera System for the National Television System Committee Standards: The Chromacoder. *P. C. Goldmark*, CBS Laboratories

CP.* National Television System Committee Color Television Transmission Via Local Wire and Microwave Facilities. *E. R. Conly, R. W. Bixler, J. H. Clark*, Pacific Telephone and Telegraph Company

2:00 p.m. Management

CP.* Organization Planning—The Hard Work and Common Sense Approach. *L. L. Perkey*, Standard Oil of California

CP.* Improving Employee Relations. *F. B. Whitman*, Western Pacific Railroad Company

2:00 p.m. Chemical, Electrochemical, and Electrothermal

CP.* Installing, Jointing, and Terminating 15-Kv Polyethylene-Insulated Power Cable. *H. W. Fahrenthold*, Brown and Root, Inc.

CP.* Economics of Hazardous Area Designations. *Harold Soliday*, The Fluor Corporation, Ltd.

CP.* Germanium Rectifiers. *R. M. Crenshaw*, General Electric Company

2:00 p.m. Medical Radiation Instruments

CP.* Hanford Radiological Instrumentation. *P. L. Eisenacher, W. A. McAdams*, General Electric Company

CP.* Electrophoretic Techniques: Some Applications and Problems. *C. A. Dubbs*, Veterans Administration Center

CP.* Localizer for Foreign Bodies and Urinary Calculi. *R. S. Mackay*, University of California Medical School

CP.* Measurements of Materials With High Dielectric Constant and Conductivity at Ultrahigh Frequencies. *H. P. Schwan, Kam Li*, University of Pennsylvania

*CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee on Technical Operations ultimately will be published in the bimonthly publications and Transactions.

CP.* A Liquid Scintillation Detector. *J. H. Knapton*, Tracerlab, Inc.

CP.* Scintillation Spectrometer Measurement of Gamma-Ray Energy. *C. S. Cook*, U. S. Naval Radiological Defense Laboratory

2:00 p.m Transmission and Distribution

54-213. Evaluation of the Integration Method for Analysis of Nonstandard Surge Voltages. *A. R. Jones*, Westinghouse Electric Corporation

54-203. Electrical Clearances for Transmission-Line Design at the Higher Voltages. *P. L. Bellaschi*, Consulting Engineer

CP.* 30 Years' Experience With Wood-Pole Transmission-Line Construction. *H. V. Strandberg*, City of Seattle, Wash.

CP.* Report of Full-Size Structure Tests on 230 330-Kv Structures. *R. G. Yerk*, Hughes Brothers

CP.* Empirical Data Obtained From Tests on Round and Dimensional Wood Members. *O. W. Sutro*, Malleable Iron Fittings Company

2:00 p.m. Magnetic Amplifiers

CP.* Domain Theory and the Magnetic Amplifier. *H. J. Hamilton*, Librascope, Inc.

CP.* Production Testing of Tape Core Materials for Magnetic Amplifiers. *J. E. Mitch, H. A. Lewis, R. A. Parnell*, The Arnold Engineering Company

54-249. Magnetic Amplifier Circuits With Full-Wave Output and Half-Wave Control Signals. *H. W. Lord*, General Electric Company

54-260. The Cyclic-Integrator—A Device for Measuring the Frequency Response of Magnetic Amplifiers. *T. Dunnegan, Jr.*, Chance Vought Aircraft, Inc.; *J. D. Harnden, Jr.*, General Electric Company

CP.* Theory of Magnetic Cross Valves. *W. H. Higa*, North American Aviation, Inc.

2:00 p.m. District 8 Branch Paper Competition

Tuesday, June 22

9:00 a.m. Section Delegates Conference

9:00 a.m. Radio Communications

54-214. Type N1 Carrier on Radio and Coaxial Cable. *W. S. Ames, W. H. Wedel*, Pacific Telephone and Telegraph Company

54-239. One Approach to a Video Superhigh-Frequency Relay System. *R. H. Coe, F. F. McClatchie*, Pacific Telephone and Telegraph Company

CP.* Subcarrier Transmission Through Television Relay Links. *S. Topol, W. J. Bickford, W. E. Marcley, W. T. Beers*, Raytheon Corporation

CP.* A 72-Channel Radio System for Telephone Toll Service. *M. C. Harp, M. H. Kebby, J. W. Halina*, Lenkurt Electric Company, Inc.

9:00 a.m. Mining and Metal Industry

CP.* Ore Conveyors at Pend O'Reille Mines and Metals Corporation. *R. M. Gilbert, A. A. Bulen*, Westinghouse Electric Corporation

CP.* Factors Affecting Choice of Mine Hoist Drives. *R. B. Moore*, General Electric Company

CP.* Reactor Control of Industrial Electrostatic Precipitators. *W. H. Strate*, Westinghouse Electric Corporation

CP.* Waste Heat Power Generation in Western Cement Plant. *J. D. Rosenblatt*, Bechtel Corporation; *R. L. Boulden*, Riverside Cement Company; *D. B. Carson*, General Electric Company

9:00 a.m. Nuclear Reactors

CP.* Propulsion Reactors. *P. N. Ross*, Westinghouse Electric Corporation

CP.* Effect of Reactivity Transients on Reactor Design. *E. F. Weisner*, North American Aviation, Inc.

54-199. Electric-Circuit Models of the Nuclear Reactor. *Gabriel Kron*, General Electric Company

CP.* Hanford Reactor Instrumentation. *E. S. Day, Jr.*, General Electric Company

CP.* The Economic Outlook for Nuclear Power. *W. H. Nutting*, Pacific Gas and Electric Company

9:00 a.m. Transmission and Distribution

54-215. Lightning Protection in a 120-Kv Station—Field and Laboratory Studies. *J. K. Dillard, A. R. Hileman*, Westinghouse Electric Corporation; *H. R. Armstrong*, Detroit Edison Company

54-220. Transient Stability Limits and Their Effects on the Choice of Conductor Size. *R. M. Butler, D. L. Hopkins*, General Electric Company

54-212. Radio Transmission on 230- and 400-Kv Lines in Sweden. *B. G. Rathsman, S. Parding, C. A. Enstrom*, Swedish State Power Board

CP.* Traveling-Wave Protection Problems II. *E. W. Boehne*, Massachusetts Institute of Technology

9:00 a.m. Magnetic Amplifiers

CP.* Magnetic Low-Level D-C Signal Converters. *H. H. Woerdemann*, Magnetic Research Corporation

CP.* A Precision Magnet Power Supply Using a Cut-Core Magnetic Amplifier. *R. Morrison, G. W. Downs*, Wm. Miller Instruments, Inc.

CP.* Current and Voltage Waveforms of Magnetic Amplifiers Operating Into Inductive and Capacitive A-C Loads. *B. M. Wolfframm*, North American Aviation, Inc.

54-237. The Operation of Magnetic Amplifiers with Various Types of Loads. Part I—Load Currents for Given Angle of Firing. *L. A. Finzi, R. R. Jackson*, Carnegie Institute of Technology

9:00 a.m. Light Traction

54-251. An Electric System for Monorail Rapid Transit. *E. H. Anson, R. L. Kimball,* Gibbs and Hill, Inc.

54-252. High-Speed Rapid-Transit Equipment. *S. J. Vouch,* General Electric Company

54-253. Rebuilding San Francisco's Transit System. *F. L. ReQua,* Public Utilities Commission, City and County of San Francisco, Calif.

CP.* The Swiss Gyrobus. *J. T. Turner, Jr.,* British Columbia Electric Company, Ltd.

2:00 p.m. Section Delegates Conference

2:00 p.m. Radio Communications

54-240. Radio Transmission of Narrow-Band Mobile Radio Systems at 40 Mc. *C. R. Kraus, W. G. Chaney, A. T. Steelman,* Bell Telephone Company of Pennsylvania

54-241. Comparative Propagation Studies on 250 and 450 Mc. *E. Hopner,* Lenkurt Electric Company, Inc.; *T. D. Cushing,* Northwest Telephone Company

54-242. Technical Considerations Relating to Marine Radiotelephone Communication for Safety. *O. T. Laube,* American Telephone and Telegraph Company

CP.* The Seattle-Victoria Radio System. *R. E. Kistler,* Pacific Telephone and Telegraph Company

2:00 p.m. Nuclear Measurements and Accelerators

CP.* Recent Developments in Transuranium Element Research. *S. G. Thompson,* University of California Radiation Laboratory

CP.* Radioactivity Measurements in Transuranium Element Research. *Albert Ghiorso,* University of California Radiation Laboratory

CP.* The Stanford Linear Electron Accelerators. *R. B. Neal,* Stanford University Microwave Laboratory

CP.* Current Accelerator Developments at the University of California. *G. M. Farly,* University of California Radiation Laboratory

CP.* The Cal Tech Synchrotron. *R. V. Langmuir,* California Institute of Technology

2:00 p.m. Transmission and Distribution

54-267. An Analysis of 14.4/24.9-Kv Grounded Y Distribution System Overvoltages. *G. G. Auer, A. J. Schultz,* General Electric Company

54-236. Overvoltages on 14.4/24.9-Kv Rural Distribution Systems. *L. B. Crann, R. B. Flickinger,* U. S. Department of Agriculture

54-278. Effect of Load Growth on Economic Conductor Size. *H. H. Hunt,* Sacramento Municipal Utility District

54-279. Some Aspects of Distribution Load Area Geometry. *F. C. Van Wormer,* General Electric Company

CP.* Simplified Capacitive Reactance Calculations. *C. B. Grund, Jr.,* Alabama Power Company

2:00 p.m. Magnetic Amplifiers

54-238. The Operation of Magnetic Amplifiers With Various Types of Loads. Part II—Controlling the Angle of Firing. The Transfer Characteristics of Amplifiers With Low Control Impedance. *L. A. Finzi, R. R. Jackson,* Carnegie Institute of Technology

54-316. Magnetic Amplifiers With Inductive D-C Load. *H. F. Storm,* General Electric Company

54-247. An Operational-Type Magnetic Amplifier for Air-Borne Servo Control Systems. *R. M. Hubbard,* Boeing Airplane Company

CP.* An Analogue Computer Technique Using Magnetic Amplifiers. *B. E. Davis, I. H. Swift,* U. S. Naval Ordnance Test Station

2:00 p.m. Relays

54-314. Simplification of A-C Vector Systems. *W. K. Sonnemann,* Westinghouse Electric Corporation

CP.* Operating Experience With 230-Kv Automatic Reclosing on Bonneville Power Administration System. *D. A. Gillies,* Bonneville Power Administration

54-250. An Electronic Distance Relay Using a Phase-Discrimination Principle. *F. R. Bergseth,* University of Washington

54-315. Distribution Feeder Ground Fault Protection Improved by Use of Zero Sequence Operator in 3-Phase Sectionalizer. *M. A. Bostwick,* Portland General Electric Company

2:00 p.m. Feedback Control Systems

CP.* Frequency Response From Transient Response. *H. Thal-Larsen,* Berkeley, Calif.

54-280. A Generalized Method for Determining the Closed-Loop Frequency Response of Nonlinear Systems. *L. T. Prince, Jr.,* Minneapolis-Honeywell Regulator Company

CP.* A Method for the Preliminary Synthesis of a Complex Multiloop Control System. *D. J. Povejsil, A. M. Fuchs,* Westinghouse Electric Corporation

54-281. An Extension of the Root Locus Method to Obtain Closed-Loop Frequency Response of Feedback Control Systems. *A. S. Jackson,* Cornell University

Wednesday, June 23

9:00 a.m. Wire Communications

54-286. Theory of E-Type Repeaters. *J. L. Merrill, Jr.,* Bell Telephone Laboratories, Inc.

54-287. E-Type Telephone Repeaters, Description Equipment and Testing. *J. O. Smethurst,* Bell Telephone Laboratories, Inc.

54-222. Negative Impedance Telephone Repeaters Application in the Bell System. *A. F. Rose,* American Telephone and Telegraph Company

54-288. Servicing Center for Short-Haul Carrier Telephone Systems. *A. L. Bonner,* Bell Telephone Laboratories, Inc.

9:00 a.m. Feedback Control Systems

54-282. Sampled-Data Processing Techniques for Feedback Control Systems. *A. R. Bergen, J. R. Ragazzini,* Columbia University

CP.* A General Theory for Determining the Change in the Stability of a Feedback Control System With Variation of Its Parameters. *T. J. Higgins,* University of Wisconsin; *T. A. Wetzel,* Kearney and Trecker Corporation

54-283. The Design of Sampled-Data Feedback Systems. *G. V. Lago,* University of Missouri; *J. G. Truxal,* Purdue University

CP.* Analysis of Errors in Sampled-Data Feedback Systems. *J. Sklansky, J. R. Ragazzini,* Columbia University

9:00 a.m. Instruments and Measurements

54-290. Accurate Tachometry Methods With Electronic Counters. *J. M. Shulman,* Westinghouse Electric Corporation

54-291. Measurement of the Quality Factor of Inductor Cores. *Chandler Stewart,* Fort Belvoir, Va.

54-208. A Simplified Standard Cell Comparator. *J. H. Miller,* Weston Electrical Instrument Corporation

54-204. The Quasi-Peak Voltmeter. *C. W. Frick,* General Electric Company

54-292. Precision Measurement of Complex Quantities in Electric Networks as a Function of Frequency. *A. J. Hermont,* Shell Development Company

9:00 a.m. Power Generation

54-301. Application of Equipment in Outdoor Steam-Electric Generating Stations. *W. D. Marsh, A. G. Mellor,* General Electric Company

CP.* Design Features of Etiwanda Steam Station of the Southern California Edison Company. *H. C. Austin,* Southern California Edison Company

CP.* Operating Experience With an Outdoor Steam-Electric Generating Plant. *A. E. Capon,* City of Burbank, Calif.

CP.* Electric Design Features of the Hawaiian Electric Company, Ltd., Steam-Electric Plant—Honolulu Unit No. 8. *G. R. Dunbar,* Westinghouse Electric Corporation; *W. J. Froome,* Hawaiian Electric Company, Ltd.; *W. C. Stivers,* Bechtel Corporation

9:00 a.m. Insulated Conductors

54-232. 300-Kv Oil-Filled Cables for Aluminum Company of Canada. *A. N. Arman,* Pirelli-General Cable Works, Ltd.

54-233. The 301-Kv All-Aluminum Oil-Filled Cables at Kemano, B. C., Canada. *H. D. Short,* Canada Wire and Cable Company; *J. T. Madill,* Aluminum Company of Canada, Ltd.

CP.* Pipe-Type Cables for Power Transmission at 230 Kv and Higher Voltages. *G. N. Everest, P. V. White,* The Okonite Company

9:00 a.m. Basic Sciences

54-297. Forced Oscillations of Nonlinear Circuits. *L. A. Pipes,* University of California

CP.* Extension of the Operational Calculus to Time-Varying Networks. *J. A. Aseltine,* Hughes Aircraft Company; *H. Davis, E. C. Ho, D. L. Trautman,* University of California

54-298. Analysis and Synthesis of Sampled-Data Control Systems. *E. I. Jury,* Columbia University

CP.* Equations for Determining Current Distribution Among the Conductors of Busses Comprised of Double-Channel Conductors. *C. M. Siegel,* University of Virginia; *T. J. Higgins,* University of Wisconsin

9:00 a.m. Semiconductors

CP.* The Use of Junction Transistors as Switches to Obtain Reliability, Interchangeability, and the Satisfaction of Military Environmental Conditions. *R. L. Bright,* Westinghouse Electric Corporation

CP.* Switching Transistors Used as a Substitute for Mechanical Low-Level Choppers. *A. P. Kruper,* Westinghouse Electric Corporation

CP.* The Use of Transistors to Improve the Stability and Sensitivity of Magnetic Amplifiers. *R. A. Ramey,* Westinghouse Electric Corporation

CP.* Transistor Demodulator for High-Performance Magnetic Amplifiers in A-C Servo Applications. *R. O. Decker,* Westinghouse Electric Corporation

9:00 a.m. Magnetic Amplifiers

CP.* A Magnetic Reference Unit. *William Woodworth,* U. S. Naval Ordnance Test Station

CP.* A Magnetic Integrator. *J. A. Crawford,* U. S. Naval Ordnance Test Station

54-248. Magnetic Frequency Multipliers. *L. J. Johnson,* Hufford Machine Works; *S. E. Rauch,* University of California

CP.* Self Bias in Balanced Magnetic Amplifiers. *C. C. Glover, D. H. Mooney, F. G. Timmel,* Westinghouse Electric Corporation

CP.* Self-Saturating Circuits With Microwatt Input. *F. M. Arnold,* Lear, Inc.

2:00 p.m. Wire Communications

54-289. Electrical Protection of Telephone Systems. *W. R. Bullard,* Ebasco Services, Inc.; *J. B. Hays,* Bell Telephone Laboratories, Inc.; *H. O. Saunders,* American Telephone and Telegraph Company

54-218. Varistor Modulators for Carrier Systems. *R. S. Caruthers,* Lenkurt Electric Company, Inc.

CP.* Combined Operation of 24-Channel Cable Carrier and 12-Channel Open Wire Systems. *G. W. Searle,* Wisconsin Telephone Company

2:00 p.m. Feedback Control Systems

54-284. Self-Oscillation Method for Measuring Transfer Functions. *J. C. Clegg, L. D. Harris,* University of Utah

CP.* Graphic Construction of Numeric Feedback System Closed-Loop Function Locus. *T. A. Wetzel,* Kearney and Trecker Corporation

CP.* Error Coefficients in the Design of Feedback Control Systems. *T. A. Savo, J. G. Truxal,* Purdue University

54-285. Measurement of Some Nonlinearities in Servomechanisms. *D. K. Gehmlich, M. E. Van Valkenburg,* University of Utah

CP.* Design and Application of a Peak Voltage Detector to Industrial Control Systems. *L. W. Allen,* International Business Machines Corporation

2:00 p.m. Synchronous Machinery

54-261. Synchronous Machine Analogues for Use With the Network Analyzer. *J. E. Van Ness,* Northwestern University

54-262. The Resistance of Twisted Segmental Amortisseur Bars. *J. C. White*, General Electric Company

54-263. Improvements in Predicting Telephone Interference Factor of Salient-Pole Machines. *J. F. H. Douglas*, Marquette University

54-264. Saturation Effects in Synchronous Machines. *Djabir Hamdi-Sepen*, Technical University of Istanbul

2:00 p.m. Insulated Conductors

54-219. High-Pressure Pipe-Type Cable Systems—The Pipe as a Structure. *R. W. Gillette*, Consolidated Edison Company of New York, Inc.; *J. E. Johnson*, Philadelphia Electric Company

54-210. Physical Characteristics of Pipe-Type Cable Faults. *R. J. Mather, J. A. Purviance*, Bonneville Power Administration

54-223. Studies Relating to the Use of Aluminum Conductors for Pipe-Type Cable. *J. Sticher, R. H. Hiester*, The Detroit Edison Company; *L. Meyerhoff, M. H. McGrath*, General Cable Corporation

54-234. Compression Y Splicing to Insulated Aluminum. *Fred Heller*, Burndy Engineering Company, Inc.

2:00 p.m. Industrial Power Systems

54-243. Problems Relating to Interconnections of Large Pulp and Paper Mills With Large Utility Power Systems. *H. A. Rose*, Westinghouse Electric Corporation; *H. E. Springer*, Rayonier, Inc.

54-244. Some Fundamentals of Equipment Grounding Circuit Design. *R. H. Kaufmann*, General Electric Company

CP.* Electric System at Ford's New Assembly Plant at San Jose, Calif. *E. Eriksrud*, Ford Motor Company; *N. A. Kieb*, Albert Kahn Associated Architects and Engineers, Inc.

CP.* Installation of Interlocked Armor Cable and Racks for Industrial Power Distribution. *F. V. Calvert*, Husky Products, Inc.; *L. F. Cudlin*, General Electric Company

CP.* Here Is Proof You Can Save on 277/480-Volt Lighting. *W. W. Henderson*, Bernard Johnson and Associates; *H. N. Hickok*, General Electric Company

2:00 p.m. Power System Measurements

54-293. A New 12-Element Automatic Oscillograph and Applications on the Bonneville Power System. *C. M. Hathaway, W. L. Davis*, Hathaway Instrument Company; *J. R. Curtin*, Bonneville Power Administration

CP.* Recent Experience With Electronic Pulse-Type Fault Locators. *R. L. Brinton*, Pacific Gas and Electric Company

CP.* Development of Standard Burden Sets for Testing Instrument Potential Transformers. *F. H. Krauss*, Electrical Facilities, Inc.; *W. Pritchett*, University of California

CP.* A New Electric Device to Detect Leaks of Inflammable Gases. *W. C. White*, General Electric Company

54-294. The Use of Sphere Gaps at Radio Frequencies. *C. B. Oler*, U. S. Naval Postgraduate School

2:00 p.m. Semiconductors

CP.* Properties of Silicon Power Diodes. *E. F. Losco*, Westinghouse Electric Corporation

CP.* A Switching Transistor D-C to A-C Converter Having an Output Frequency Proportional to the D-C Input Voltage. *G. H. Royer*, Westinghouse Electric Corporation

CP.* A High-Accuracy Static Time-Delay Device Utilizing Transistors. *G. F. Pittman, Jr.*, Westinghouse Electric Corporation

Thursday, June 24

9:00 a.m. Communication Switching Systems

54-273. Application of Toll Dialing in Pennsylvania. *A. L. Charny*, Bell Telephone Company of Pennsylvania

CP.* A PBX Telephone Switchboard for Dispatching Service. *F. W. Treptow*, Bell Telephone Laboratories, Inc.

CP.* Concentrator-Identifier as Applied to Telephone Answering Service. *D. H. MacPherson*, Bell Telephone Laboratories, Inc.

C.P.* Dial Concentrator Switching. *E. J. Ward*, Interstate Engineering Corporation

54-207. Switching Functions on an n-Dimensional Cube. *C. Y. Lee*, Bell Telephone Laboratories, Inc.

9:00 a.m. Instrumentation

CP.* An Air-Borne Temperature Indicator. *W. R. Clark, W. G. Amey, G. C. Mergner*, Leeds and Northrup Company

54-295. Stabilized Power Supplies for Instrument Applications. *W. G. Amey, F. H. Krantz, W. R. Clark, A. J. Williams, Jr.*, Leeds and Northrup Company

54-296. Thickness Gauge for Dielectric Materials. *W. W. Woods*, Boeing Airplane Company

CP.* A Survey of Noncontacting Vibration Pickups Using Electric Fields. *H. F. Clarke*, Boeing Airplane Company

CP.* A New System for Monitoring the Over-all Transduction Ratio for Analogue Recording Channels Employing Bridge-Type Transducers. *A. T. Snyder*, Boeing Airplane Company

9:00 a.m. Power Generation

54-299. Nondestructive Testing of Water-Wheel Generating Unit Mechanical Components. *T. C. Stavert*, Southern California Edison Company

54-300. Maximizing Income From Water-Wheel Generators. *K. R. Knights*, Hydro-Electric Power Commission of Ontario; *V. W. Ruskin*, Canadian Brazilian Services

CP.* Development of Small Hydroelectric Sites in Western North Carolina. *H. H. Gnuse, Jr.*, Nantahala Power and Light Company

CP.* Tennessee Valley Authority Experiences With Vertical Hydro-Generator Thrust Bearings. *C. L. Norris, L. R. Sellers, A. P. Maness*, Tennessee Valley Authority

9:00 a.m. Electric Space Heating

CP.* Design and Operation of Electric Radiant Heating Systems. *G. K. Brokaw*, Consulting Engineer

CP.* Electric Heat Utility Problems. *J. R. Bonnin, Lacey Peoples*, Cowlitz County Public Utility District No. 1

CP.* Cost of Serving Residential Customers and Design of Electric Rate Schedules. *H. B. Cockerline*, Oregon State College; *Jim Howell*, Eugene Water and Power Board

9:00 a.m. Safety

54-206. Placement of Protective Grounds for Linemen Safety. *E. J. Harrington, T. M. C. Martin*, Bonneville Power Administration

CP.* Grounding of Portable Electric Equipment. *H. H. Watson*, General Electric Company; *L. S. Inskip*. Bell Telephone Laboratories, Inc.

CP.* Effect of Grounding on Accident Experience in California Industry. *E. E. Carlton*, State of California

54-209. The Threshold of Perception Currents. *C. F. Dalziel*, University of California. Re-presented for discussion

9:00 a.m. Protective Devices

54-201. Analytical Expressions for the Resistance of Grounding Systems. *S. J. Schwarz*, Sverdrup and Parcel, Inc.

54-302. Surge Protection of Transformers Based on New Lightning Arrester Characteristics. *J. K. Dillard, T. J. Bliss*, Westinghouse Electric Corporation

54-303. A Semiempirical Formula for Calculating Distribution-Transformer Fuse Ratings With Respect to Lightning Surges. *John Zaborszky*, Missouri School of Mines and Metallurgy

9:00 a.m. Theory of Economical Loading of Power Systems

CP.* Use of Storage Water in Hydroelectric Systems. *John Little*, Massachusetts Institute of Technology

54-259. Analysis of Methods of Storage Use to Obtain Maximum Incremental Energy From Two Hydro Storage Plants. *B. V. Hoard*, Bonneville Power Administration

54-274. Short-Range Load Allocation on a Hydro-Thermal Electric System. *J. J. Carey*, University of Michigan

CP.* A Critique of Optimization Methods for Hydro-Thermal Systems. *E. W. Boehne, P. Schweitzer*, Massachusetts Institute of Technology

CP.* Water Regulation and Load Allocation in the Pacific Northwest. *Carl Blake, Lyle Dunstan*, Bonneville Power Administration

2:00 p.m. Applications of Computers to Power System Operating Problems

54-275. An Analogue Computer for Automatic Determination of System Swing Curves. *D. W. C. Shen*, University of Adelaide; *S. Lisser*, Electricity Trust of South Australia

54-276. Automatic Digital Computer Applied to Generation Scheduling. *A. F. Glimn, L. K. Kirchmayer, R. Habermann, Jr.*, General Electric Company; *R. W. Thomas*, Southwestern Public Service Company

54-224. Loss Evaluation—III. Economic Dispatch Studies. *R. H. Travers*, Ohio Edison Company; *D. C. Harker*, Commonwealth Associates, Inc.; *R. W. Long, E. L. Harder*, Westinghouse Electric Corporation

54-277. Computer Search for Economical Operation of a Hydro-Thermal Electric System. *R. J. Cypser*, International Business Machines Corporation

2:00 p.m. Carrier Current

54-228. Analysis of Losses in Power-Line Carrier Coupling Circuits. *F. C. Krings, J. L. Woodworth*, General Electric Company

54-227. An Objective Study of Power-Line Carrier Coupling Methods. *D. O. Herbert, J. C. G. Carter*, Westinghouse Electric Corporation

54-226. Practical Use of Selectivity Data in Spacing Power-Line Carrier-Current Control Channels. *D. C. Pinkerton*, General Electric Company

54-230. Time-Division Microwave Communications for an Electric Power System. *H. D. Ashlock*, Public Service Company of Indiana; *I. T. Corbell*, General Electric Company

2:00 p.m. Rotating Machinery

54-265. Destructive A-C and D-C Tests on Two Large Turbine Generators of the Southern California Edison Company. *K. M. Stevens*, Southern California Edison Company; *J. S. Johnson*, Westinghouse Electric Corporation

CP.* Impedance Testing of Synchronous Machine Rotor Windings. *William Schneider*, Westinghouse Electric Corporation

54-266. Thermal Endurance of Silicone Magnet Wire Evaluated by Motor Test. *W. J. Bush, J. F. Dexter*, Dow Corning Corporation. Re-presented for discussion

54-202. Quantitative Analysis of Carbon Brush Treatments Using X-Ray Photometer Absorption Method. *A. C. Titus*, General Electric Company. Re-presented for discussion

2:00 p.m. Transformers

54-245. Leakage Reactance of Irregular Distributions of Transformer Windings by the Method of Double Fourier Series. *A. Boyajian*, Consulting Engineer

54-205. Parallel Operation of Load Ratio Control Transformers Using Reverse Reactance Compensation. *W. C. Sealey*, Allis-Chalmers Manufacturing Company

54-211. 25,500-Kvar Coreless Reactor for Canada–United States Link. *A. B. Trench, L. J. MacKinnon*, Canadian General Electric Company, Ltd.

54-246. Mechanical Forces in Interleaved Rectangular Pancake Transformer Coils. *R. L. Bean, E. C. Wentz*, Westinghouse Electric Corporation

CP.* Cell Construction for Current-Limiting Reactors. *L. E. Sauer*, Westinghouse Electric Corporation

2:00 p.m. Electronic Circuitry

CP.* Notes on the Use of Screen-to-Plate Transconductance in Multigrid Circuit Design. *K. A. Pullen, Jr.*, Aberdeen Proving Grounds

54-268. Closed-Loop Automatic Phase Control. *P. F. Ordung, J. G. Gibson, B. J. Shinn*, Yale University

54-269. Shaping of the Characteristics of the Temperature-Sensitive Elements. *E. Keonjian, J. S. Schaffner*, General Electric Company

CP.* Application of Transistors to Telemetering Systems. *C. M. Kortman*, Bendix Aircraft Corporation

CP.* Plug-in Units for Digital Computing Systems. *J. N. Harris*, Massachusetts Institute of Technology

2:00 p.m. Heat Pumps

54-225. Air Ionization as an Environment Factor. *J. C. Beckett*, Wesix Electric Heater Company

CP.* Heat Pump Experience in the Sacramento, Calif., Area. *M. N. Davis*, Sacramento Municipal Utility District

CP.* Use of the Heat Pump for Digester Heating. *G. S. Smith*, University of Washington

Friday, June 25

9:00 a.m. Computing Devices

54-270. Transistor Building Blocks for Analogue Computers. *H. Hellerman*, Syracuse University. Re-presented for discussion.

54-271. Magnetic Drum Recording of Digital Data. *A. S. Hoagland*, University of California

CP.* Voltage Coders and Decoders. *Bernard Lippel*, Evans Signal Laboratory

54-272. Networks for Digital-to-Analogue Shaft-Position Transducers. *S. J. O'Neil*, Air Force Cambridge Research Center

54-313. Precision High-Current Computer Power Supplies. *Allen Rosenstein*, University of California

9:00 a.m. System Engineering

54-216. The Planning of the Swedish Extra-High-Voltage System. *B. G. Rathsman, G. Jancke, S. Lalander*, Swedish State Power Board

54-254. Integration of High-Voltage Systems in Britain. *D. P. Sayers, F. J. Lane*, British Electricity Authority

54-255. Integration of High-Voltage Transmission Lines Within Bonneville Power Administration 230-Kv Grid. *G. C. Conner, R. S. Seymour*, Bonneville Power Administration

CP.* A Look into the Future of Power Transmission in the West. *H. D. Hunkins*, Bureau of Reclamation

9:00 a.m. Switchgear

54-256. Capacitor Switching Phenomena With Resistors. *R. C. Van Sickle*, Westinghouse Electric Corporation; *J. Zaborszky*, University of Missouri

54-231. High-Voltage Oil Circuit Breakers With Resistance-Equipped Interrupters for Capacitor Switching. *W. M. Leeds, G. B. Cushing*, Westinghouse Electric Corporation

54-229. Switches for 300 to 500 Kv—Some New Design Concepts. *A. Foti, E. A. Williams*, Railway and Industrial Equipment Division, I-T-E Circuit Breaker Company

9:00 a.m. Air Transportation

CP.* High-Frequency Alternators. *S. E. Rauch*, University of California; *L. J. Johnson*, D. & R. Ltd.

CP.* Co-ordinated Aircraft A-C Electric Systems. *P. F. Boggess, C. L. Mershon*, Westinghouse Electric Corporation

CP.* Magnetic-Amplifier-Type Voltage Regulator for Aircraft A-C Generators. *W. G. Evans, G. H. Stearley*, Westinghouse Electric Corporation

54-305. Transient Characteristics of Aircraft A-C Generators. *V. C. Holloway*, U. S. Naval Research Laboratory

54-306. Economic Factors for Aircraft Electric Power Systems. *R. M. Bergslien, L. J. Stratton, H. J. Finison*, Armour Research Foundation of Illinois Institute of Technology. Re-presented for discussion

54-307. A Method of Calculating Current Limiter and Fuse Clearing Times in A-C Systems. *S. C. Caldwell, L. E. Jensen*, General Electric Company. Re-presented for discussion

54-308. Evaluation of Designs for Intermittently Heated Surfaces. *T. M. Dahm, R. A. Holloway*, Lockheed Aircraft Corporation. Re-presented for discussion

54-217. Performance of a Constant-Speed Drive. *E. W. Giloy*, The Glenn L. Martin Company. Re-presented for discussion

9:00 a.m. General Industry Applications

54-221. Remote Operation of Pipe-Line Pumping Stations. *W. A. Derr, M. A. Hyde*, Westinghouse Electric Corporation

CP.* New Packaged Amplidyne-Controlled Log Carriage Drive for the Small Sawmill. *D. C. Burke*, Portland General Electric Company

CP.* Basic Advantages of the New Mechanical Magamp Speed-Matching System for Sectional Paper Machine Drives. *W. Schaelchlin, M. H. Fisher*, Westinghouse Electric Corporation

CP.* Control Circuit Design and Application for Automatic Sulphite Pulp Bleaching. *K. D. Watt, J. P. Doyle*, Alaska Pine and Cellulose Ltd.

2:00 p.m. Computing Devices

CP.* Survey of High-Speed Analogue Voltage Conversion Devices. *D. W. Slaughter*, California Institute of Technology

CP.* Two Versatile Digitizing Circuits. *M. L. Kuder*, National Bureau of Standards

CP.* A High-Speed Analogue-to-Digital Converter. *James Mitchell*, J. B. Rea Co., Inc.

CP.* Punched-Card Potentiometer-Setting Device. *Eric Weiss*, Dynalysis, Inc.

2:00 p.m. System Engineering

CP.* Observations on Transmission System Expansion. *D. K. Blake, R. M. Butler, R. A. Schmidt*, General Electric Company

54-235. Extra-High-Voltage Transmission and System Planning. *C. F. Wagner, J. E. Barkle, T. J. Bliss*, Westinghouse Electric Corporation

54-257. Design and Operation of System-Wide Automatic Load-Frequency Control. *H. A. Bauman, C. N. Metcalf, J. G. Noest*, Consolidated Edison Company of New York, Inc.; *J. B. Carolus*, Leeds and Northrup Company

54-200. Power System Fault Current Analysis Including Study of Transient Offset. *M. J. Lantz*, Bonneville Power Administration

54-258. Characteristics of Impulse Communications and Control Systems. *R. L. Mayer*, Pacific Gas and Electric Company

2:00 p.m. Switchgear

CP.* Metalclad Switchgear Adds Further Safety With Flame-Retardant Insulation. *C. P. West*, Westinghouse Electric Corporation

CP.* Part Testing of High-Voltage Circuit Breakers. *D. C. Prince*, Pacific Oerlikon Company

54-304. Field Tests on 138-Kv Swedish Low-Oil-Content Circuit Breakers. *L. R. Bergstrom*, Allmänna Svenska Electriska Aktiebolaget; *G. A. Stockwell*, City of Los Angeles; *H. H. Mitchell*, Kelman Electric and Manufacturing Company

2:00 p.m. Air Transportation

CP.* Generator Developments for High-Performance Aircraft. *R. J. Eschborn*, Jack and Heintz, Inc.

CP.* Developments Leading to Improved Ratings of Aircraft D-C Generators. *C. D. Fearnot, H. L. Shambach*, General Electric Company

CP.* Recent Developments in the Testing of Aircraft Generating Equipment. *R. S. Thacker*, R. S. Thacker Company

54-317. A Self-Excited Induction Generator With Regulated Voltage. *H. M. McConnell*, Carnegie Institute of Technology

54-309. Study of a Transformerless Rectified Higher Voltage D-C Aircraft Electric System. *J. P. Dallas, C. A. Reising, Jr.*, Hughes Aircraft Company. Re-presented for discussion

54-310. Development of an Air-Borne Stabilized Camera. *J. H. Miller, A. J. Alexander*, Goodyear Aircraft Corporation. Re-presented for discussion

54-311. Sensitivity Requirements of Reactive Load Division Circuits in Aircraft Electric Systems. *E. S. Sherrard*, U. S. Naval Research Laboratory. Re-presented for discussion

52-319. Characteristics of Aircraft A-C Generators. *L. J. Stratton, L. W. Matsch*, Armour Research Foundation of Illinois Institute of Technology. Re-presented for discussion

54-312. Considerations Applicable to Automatic Paralleling of Aircraft A-C Generators. *M. J. Powell, E. W. Giloy*, The Glenn L. Martin Company. Re-presented for discussion

2:00 p.m. Special Communications Applications

CP.* The Electrical Flair of the 1740's: A Forgotten Wave of Spectacular Discovery Which Marked the Beginning of the Electrical Age. *Lloyd Espenschied*, Bell Telephone Laboratories, Inc.

CP.* Magnetic Tape Data Recording Systems. *L. L. Fisher*, J. B. Rea Company, Inc.

CP.* Plan 6 Receiving Teleprinted Concentrator. *R. D. Swanson*, Western Union Telegraph Company

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(*Continued from page 558*)

When completed it will consist of four generating units: numbers 1 and 2 rated 100,000 kw each, numbers 3 and 4 rated 156,250 kw each. It is expected that unit 1 will be in operation during the inspection trip, unit 2 in process of assembly and construction, and work well under way on units 3 and 4. Application of centralized control, unit auxiliary power supply system, and control of stack discharge are among features of interest.

During this trip a stopover will be made at Department of Water and Power Receiving Station "G." This is one of ten similar stations within the Los Angeles load area receiving bulk power at transmission voltages from the generating sources and distributing this power at 34.5 kv to substations and industrial customers. The ultimate design for each station provides for a capacity of 240,000 kw with each station supplied directly from a source of generation. The stations are interconnected with two 138-kv Belt Line circuits to provide for interchange of power between stations best to utilize generating facilities. Rack structures at Receiving Station "G" are of modular design using standardized rolled shapes. This design minimizes engineering, fabrication, and maintenance costs and presents an improved appearance for stations located in developed areas. Control-room lighting is an original design of luminous ceiling.

Lockheed Aircraft Corporation (Thursday, June 24, 8:30 a.m. and 1:30 p.m., $1.00). Design of modern aircraft poses mathematical problems which can be solved only by computers of many types. Lockheed Aircraft Corporation maintains a mathematical analysis section in their engineering headquarters building. A general-purpose analogue computer, differential analyzers, amplifier and digital types, and an International Business Machines Selective Sequence Computer are available to aid in the solution of problems in flow, vibration, stress analysis, and control, among others. Attendance will be limited to United States citizens and due to restricted space will not include wives or children. The first 80 reservations received will be permitted to make the trip. While part of the group inspects the computers the others will tour a portion of the factory.

North American Aviation, Inc. (Thursday,

June 24, 1:30 p.m., $1.00). North American Aviation's main plant at the Los Angeles International Airport houses the assembly line for three of the company's most widely known airplanes: the Korea-famed *F-86-F* Sabre Jet, which fought as both a day fighter and as a fighter bomber; the *F-86-D* Sabre Jet, the nation's first 1-man interceptor for all-weather defense of the nation; and the new *F-100* Sabre—holder of the world's speed record of 755.149 miles per hour and the first Air Force production airplane to operate faster than the speed of sound in level flight.

Other facilities at the plant include a supersonic wind tunnel, an altitude test chamber which duplicates temperature and pressures found at altitudes up to 85,000 feet, a structural testing laboratory, and a thermodynamics laboratory for research in temperature, flow, and pressure phenomena.

California Institute of Technology (Friday, June 25, 9:00 a.m., $1.00). Located in Pasadena, the California Institute of Technology is a 20-minute ride from meeting headquarters along the pioneer of all California Freeways, the Arroyo-Seco. Principal points of interest for this trip will be

1. The High-Voltage Laboratory, which was the first of its type in the country to produce 1,000,000 volts at power frequency. Available for research as well as industrial tests, the laboratory has made an outstanding contribution to the industrial growth of Southern California.
2. The Synchrotron, which accelerates electrons over a distance of 45,000 miles, approaching the speed of light and attaining the energy of a billion electron-volts. The Synchrotron is playing an important role in nuclear investigation.
3. The Analysis Laboratory houses the electric analogue computer, a general-purpose device having a very wide field of application. It is particularly useful in solving problems of aircraft design and is used extensively by most of Southern California's aircraft companies.
4. The Hydrodynamics Laboratory contains extensive equipment for the study of the hydrodynamic forces on the models of bodies moving on the surface of the water, or with shallow submergence, as well as for other hydrodynamic problems.
5. The Guggenheim Aeronautical Laboratory contains several wind tunnels capable of operating up to speeds as high as 11 times that of sound. The tunnels are being used in fundamental research for the U.S. Army and Air Force.

SPORTS

Golf has been arranged for the registered AIEE members and their guests. On Tuesday, June 22, golf players will tee off starting at 11:00 a.m. at the Wilshire Country Club. Golfers should register at the Sports Information Desk for starting time and transportation, if desired. All registered members and guests are invited to participate in the golf tournament. Registered male members of Districts 8 and 9 (Pacific Coast members) are eligible to compete for the J. B. Fisken cup, a perpetual trophy. The Fisken cup is awarded for low net score, 18 holes Medal play. There will be prizes for low gross, low net, and blind bogey scores, open to all players. Any golfers desiring noncompetitive golf on days other than June 22 should consult with the Sports Desk for arrangements. Full use of all club facilities by the players has been arranged. Locker space and rental clubs for members will be available.

Tennis, swimming, and horseback riding will be available to those wishing their daily exercise. If advance notice indicates sufficient players are interested, a tennis tournament can be arranged to be played on June 22. Deep-sea fishing has attractions for some and if enough interest is indicated a party will be scheduled.

The golf prizes will be awarded at the banquet on Thursday.

TRANSPORTATION

Special flights to the meeting are being organized and members are urged to check with local air-lines offices to secure space. Similarly, sections on trains are being made available and local railroad offices can give advice about such accommodations.

The airport busses from both International and Lockheed airports terminate at the Biltmore Hotel, meeting all airplanes. For those who travel by automobile, there is garage parking space for 4,000 cars within one block of the Biltmore.

The Transportation Committee is answering all inquiries regarding points of interest which may be seen en route whether traveling by air, train, or automobile. Such inquiries should be addressed to: Robert A. Young, Transportation Chairman, 3905½ San Fernando Road, Glendale 4, Cal

ADVANCE REGISTRATION

The Registration Desk will be open in the Biltmore Galeria from 2:30 p.m. to 5:00 p.m., Sunday, June 20, and daily from 8:30 a.m. to 4:30 p.m. thereafter for the duration of the meeting. The registration fee is $3.00 for members and $5.00 for nonmembers. No fees will be required from students or families of members. *Do not enclose remittance. Fees will be collected when registering. It will materially aid the committees if members indicate on the advance registration card the number of people and trips and activities in which they are interested in participating.*

COMMITTEE MEMBERS

Members of the 1954 Summer and Pacific General Meeting Committee are: Bradley Cozzens, general chairman; E. K. Sadler, vice-chairman; Clarence Wells, Secretary; E. W. Rockwell, treasurer; C. M. Allen, entertainment; Charles Croft, hotels; R. L. Engel, inspection trips; L. L. Grandi, students; G. B. Kirkwood, sports; H. A. Lott, finance; Robert Milmoe, arrangements; E. W. Morris, technical program; Elmer Niemoeller, publicity; H. E. Wheeler, registration; R. A. Young, transportation; Mrs. E. K. Sadler, ladies' events; D. I. Cone, Thomas Ingledow, F. O. McMillan, R. W. Sorensen, and G. C. Tenney, members-at-large.

AIEE Board of Directors Holds Regular Meeting in Chicago

The regular meeting of the AIEE Board of Directors was held in the Conrad Hilton Hotel, Chicago, Ill., on April 7, 1954.

The following resolution was adopted in memory of Past President A. M. MacCutcheon, who died on March 19, 1954:

Resolved: That, upon behalf of the membership of the American Institute of Electrical Engineers, the Board of Directors hereby expresses deepest regret at the death of Alexander M. MacCutcheon (AM '12—M '15—F '26), Director 1928–32, President 1936–37, and Lamme Medalist, 1947; and that sincere sympathy be extended to the members of his family.

EXECUTIVE COMMITTEE

Executive Committee actions on membership applications were reported and confirmed, as follows: As of February 26, 1954—51 applicants transferred and 3 elected to grade of Member; 192 applicants elected to grade of Associate Member; 12 Associate Members re-elected; 58 applicants elected to grade of Affiliate; 167 Student members enrolled.

BOARD OF EXAMINERS

Recommendations adopted by the Board of Examiners at meetings held on February 18 and March 18, 1954, were reported and approved. The following actions were taken, upon recommendation of the Board of Examiners: 33 applicants transferred and 5 elected to grade of Member; 1 Member re-elected; 1 applicant transferred and 207 applicants elected to grade of Associate Member; 888 Student members elected to grade of Associate Member; 20 Associate Members re-elected; 35 applicants elected to grade of Affiliate; 309 Student members enrolled.

The Board of Examiners submitted seven proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite the seven following Members to be transferred to the grade of Fellow:

Ross Duncan Brown, Chief Engineer, Monongahela Power Company, Box 1392, Fairmont, W. Va.

James DeKiep, Vice-President, Electric Machinery Manufacturing Company, 800 North Central Avenue, Minneapolis 13, Minn.

James E. Dingman, Vice-President and General Manager, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y.

Charles T. Hatcher, Division Engineer, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.

John V. L. Hogan, President, Hogan Laboratories, Inc., 155 Perry Street, New York 14, N. Y.

Louis Norman Grier, Chief Electrical Engineer, Aluminum Company of America, 1501 Alcoa Building, Pittsburgh 19, Pa.

George R. Town, Associate Director, Engineering Experiment Station, Iowa State College, Ames

More information regarding the aforenamed individuals appears under "AIEE Fellows Elected" (*pp. 570–2*).

FINANCES

Treasurer Walter J. Barrett, who was

unable to attend the meeting, submitted a report for the period January 1 to April 1, 1954, copies of which were distributed.

Chairman C. S. Purnell of the Finance Committee reported disbursements from general funds as follows: February, $104,867.83; March, $93,302.87. The report was approved.

Copies of a comparative statement of income and expenses were distributed. It showed that the income to March 31, 1954, was $384,940, or 32.6 per cent of the estimated income for the appropriation year, ending September 30, compared with 32.8 per cent last year. Expenses for the 6 months ended March 31, 1954, were $612,870, or 48.5 per cent of the estimated expenses for the appropriation year, compared with 50 per cent last year.

The following resolution was adopted to extend the time for payment of dues for the present fiscal year:

Resolved: That the names of members in arrears on May 1, 1954, for dues of the fiscal year which began May 1, 1953, be removed from the active membership list as required in the Institute Bylaws and that the time for the payment of such dues be extended until further action by the Board.

ACTIONS AND APPOINTMENTS

The Board voted that the next meeting of the AIEE Board of Directors be held on Thursday, June 24, 1954, during the Summer and Pacific General Meeting in Los Angeles, Calif., and that the incoming officers and the past presidents be invited to the Board meeting and luncheon.

The Board confirmed the appointment by the President of the Committee of Tellers, as follows, to count and report on the ballots cast in the election of Institute officers: James Nesmith, II (chairman), Donald C. Aker, John E. Brennan, H. H. Hennell, Thomas May, Henry A. Schumacher, James M. Walsh, Mrs. C. U. Watts, K. D. Young, C. J. Zeller.

The Board of Directors elected N. S. Hibshman to be Secretary of the Institute effective May 1, 1954, in anticipation of the retirement of H. H. Henline. The Board tendered a rising ovation to the retiring Secretary after expressions of appreciation were offered by Vice-President Hooven.

Upon recommendation of the Committee on Planning and Co-ordination, the Board approved the dates of May 4, 5, and 6, 1955, for the District 2 meeting to be held in Columbus, Ohio.

The Board reappointed Professor J. F. Calvert as AIEE representative on the Washington Award Commission for a 2-year term beginning June 1, 1954. L. F. Hickernell was appointed AIEE alternate representative on the World Power Conference, Executive Committee of the U. S. National Committee. N. S. Hibshman was appointed as AIEE representative on Engineers Joint Council (EJC), and Frank R. Benedict as alternate.

The President was authorized to nominate one delegate and two alternates to represent EJC at the third UPADI Convention in Sao Paulo, Brazil, August 2-12, 1954.

At the request of the secretary of The American Society of Mechanical Engineers (ASME), the Board voted to appoint A. C. Monteith and N. S. Hibshman as AIEE representatives on the committee for the promotion of the proposal of George Westinghouse for the Hall of Fame.

Middle Eastern District Meeting Committee

The Executive Committee for the 1954 AIEE Middle Eastern District Meeting, to be held in Reading, Pa., October 5–7, confers on plans and arrangements for the coming conference. Seated, left to right: W. B. Morton (chairman), Mrs. J. O. Leslie, Mrs. J. B. Homsher, Mrs. R. E. Neidig, Mrs. D. L. Greene, R. E. Neidig (vice-chairman). Standing, left to right: D. L. Greene, F. S. Fehr, H. D. Moore, S. J. Litrides, W. L. Donaldson, L. L. Nonemaker, W. S. Kerchner, J. Gabriel, P. H. Robbins, E. O. Eschbach, J. C. Gray, E. F. Weaver

Pursuant to recommendations from an informal meeting of 48 members of the governing boards and staffs of United Engineering Trustees (UET), American Society of Civil Engineers (ASCE), American Institute of Mining and Metallurgical Engineers (AIME), ASME, AIEE, and the American Institute of Chemical Engineers (AIChE), the Board of Directors approved the following resolutions:

Resolved that the Board of Directors of AIEE authorizes its President to join with the presidents of ASCE, AIME, ASME, and AIChE in the formation of a Committee of the Five Presidents for the purpose of expediting the determination of a location and other questions necessary for a joint decision by the boards of the five societies relative to providing an adequate engineering center building.

Resolved Further:

(*1*) That the representatives of AIEE on the Board of UET be instructed to ask that UET make a report to the Committee of the Five Presidents of progress in implementing the plan outlined in the memorandum from UET titled "The Future Home of the Engineering Societies," dated March 5, 1953; and

(*2*) That, the representatives of AIEE on UET be instructed to advise UET of the existence and purpose of the Committee of the Five Presidents and to request UET to co-ordinate its operations with the committee in regard to a new engineering societies center building; and

(*3*) That, in anticipation of the announcement by the Committee of the Five Presidents of a co-ordinated position of the five societies, AIEE rescinds its responses to the seven questions propounded in the UET memorandum of March 5, 1953, and all similar actions pertaining to the same subject.

A resolution from the Pittsburgh Post of The Society of American Military Engineers, March 5, 1954, was heard and received by the Board of Directors.

The Standards Committee reported approval of the following Standards:

Revision of AIEE No. *1*, "General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machines and Other Equipment"

New AIEE No. *1C*, "Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery"

New American Standard *Y32.2*, "Graphical Symbols for Engineering Diagrams," to supersede the present *Y32.1.1*, *Z32.3*, *Z32.5*, *Z32.10*, and *Z32.12*

An addenda to the previously approved Underwriters Laboratories "Standard for Flexible Cord and Fixture Wire"

The Standards Committee reported the appointment of the following representatives on standardizing committees:

Sectional Committee *B32*, "Wire and Sheet Metal Gauges"
M. S. Hancock, additional alternate

ASA Mining Standards Board
A. C. Muir, reappointed representative
L. H. James, alternate to succeed F. C. Nicholson, resigned

ATTENDANCE

Present at the meeting were: *President* Elgin B. Robertson; *Past President* F. O. McMillan; *Vice-Presidents* C. P. Almon, Jr., A. S. Anderson, W. L. Cassell, W. Scott Hill, M. D. Hooven, Walter B. Morton, G. C. Tenney; *Directors* F. R. Benedict, D. I. Cone, R. F. Danner, D. D. Ewing, L. F. Hickernell, A. C. Muir, C. S. Purnell, E. W. Seeger, J. C. Strasbourger; *Secretary* H. H. Henline; and *Assistant Secretary* N. S. Hibshman.

Electrical Problems Considered at Southern Textile Conference

The Southern Textile Conference was held at the A. French Textile School, Georgia Institute of Technology, Atlanta, April 15–16, 1954, with a registered attendance of 125.

The first morning session on April 15 was presided over by Swaffield Cowan, chairman of the Textile Industry Subcommittee, with the welcoming address by Colonel Blake R. Van Leer, president of Georgia Institute of Technology. Papers for the morning session were "Circuit Breakers as Applied to Textile Mills" and "High-Interrupting-Capacity Fuses." The discussion of these two papers was held jointly, and it

became quite lively concerning the matter of protecting old obsolete breakers which are now on circuits having short-circuit interrupting capacity in excess of breaker rating, with either high-interrupting-capacity fuses or modern circuit breakers. Because of interest in this subject it was proposed that it be made a topic for a full session next year.

The afternoon session was presided over by H. S. Colbath, and the papers covered "Multimotored Slasher Drive With Magnetic Amplifier Tension Control," "Slasher Instrumentation," and "New Developments in Electric Equipment of Value to the Textile Mills." Considerable discussion from the floor also followed these papers.

The Friday morning session was presided over by Dan McConnell and the papers covered, "Building Motors to the New National Electrical Manufacturers Association (NEMA) Standards," "Electrical Modernization in a Textile Mill," and "The Problems of the Plant Electrician." All of these papers covered subjects very close to the daily work of textile operating men. This was followed by a discussion panel on "Mill Electrical Problems," and was moderated by Mr. McConnell. Topics were varied and ran the gamut from a comparison of lead acid versus nickel iron storage batteries to the economical limit of power factor correction.

At this conference a short report was presented on the development of standards for the enclosures of mill control equipment, pointing out that at the present time the NEMA standards are in the process of revision and within a month or so it is anticipated that major changes would be made in the NEMA standards. This trend of enclosure development is in general accord with the recommendations made at past conferences by the Textile Subcommittee, and is the outgrowth of a Joint AIEE-NEMA Committee on textile mill control enclosures. This topic was presented by Mr. Cowan.

A new project subcommittee has been organized with the thought of eventually arriving at standardization for the electric equipment and design of integrally wired and equipped textile machinery. The first draft of such a standard has been prepared to be used for the purpose of soliciting comments directly from users of such equipment.

A luncheon was held the first day with E. S. Lammers of the Westinghouse Electric Corporation as toastmaster. Mr. Lammers is nominee for District vice-president. Guest speaker was Robert L. Dobb, head coach at the Georgia Institute of Technology.

Members of the AIEE Rubber and Plastics Subcommittee, front row, left to right: R. F. Snyder, W. S. Watkins, A. G. Seifried (chairman), K. W. John, V. S. Sywulka (secretary). Middle row, left to right: E. W. Wilson, L. F. Lewis, M. H. Fisher, F. C. Timberman, P. T. Powell. Back row, left to right: O. M. Bundy, C. E. Robinson, E. T. Scholze, L. E. Buess, A. G. Payne

Sixth Annual Meeting Held on Rubber and Plastics Industries

With a total registration of 211, including nine Student members from the University of Akron, the Sixth Annual Rubber and Plastics Technical Conference was held on April 5–6, 1954, at the Mayflower Hotel, Akron, Ohio.

Highlights of the meeting included the banquet at which Dr. G. E. Shriver, United States Rubber Company, discussed "The Future of Synthetic Rubber," and the inspection trip through the Firestone Tire and Rubber Company.

At a meeting of the AIEE Rubber and Plastics Subcommittee after the conference, a vote for the best paper presentation was taken with the following results:

First: "Training the Engineering Graduate in Industry," by A. W. Carpenter, The B. F. Goodrich Company

Second: "Recent Developments in Motor Insulation for Rubber and Plastics Service," by William Schneider, Westinghouse Electric Corporation

Third: "Magnetic Clutch-Brakes on Rubber Mills," by A. E. Lillquist, Cutler-Hammer, Inc.

Honorable mention also was accorded "Motivation and Morale—Your Responsibility," by Dr. E. L. Stromberg, The B. F. Goodrich Company. However, since this paper was not technical and did not deal directly with electrical engineering problems in the rubber and plastics industries, it was not included in the voting for the best paper.

W. S. Watkins, The Ohio Rubber Company, was selected as subcommittee chairman for 1955.

All introductory remarks and informal discussion after each paper were recorded on tape and the entire conference proceedings will be published at $3.50 per copy.

Boston Section Sponsors 1953–54 Educational Program

The AIEE Boston Section reports a very successful 1953–54 educational courses program. Under this program evening courses are sponsored by the Boston Section principally for its members though others also are invited to attend.

The Educational Courses Committee was started in 1946 and for 6 years Professor C. L. Dawes of Harvard University was its chairman. Each year the attendance has been most encouraging.

In September 1953 two courses were offered. Hollis Baird of Northeastern University was the instructor in the "Fundamental Principles of Television Receivers" attended by 22 persons. "Engineering Economics," a practical course in applied engineering economics, was given by B. W. Whitehurst, Stone and Webster Engineering Corporation. This course was attended by 34. Each course consisted of 12 meetings for 2 hours each.

A 6-session course, "Transistor Fundamentals," was presented by Seymour Schwarz, Massachusetts Institute of Technol-

Professor R. E. Scott (center) demonstrates equipment in the Computer Laboratory at the Massachusetts Institute of Technology to classes sponsored by the Boston Section

Lamme Medal Nominations for 1954 Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1955, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal Committee as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that: "The committee in making the award shall carefully observe the limitation imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electrical apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electrical apparatus or machinery. Any work which meets this requirement is admissible whether it be (a) in development of the theory involved; (b) in development of the characteristics of the materials employed; (c) in development of over-all design; or (d) in development in other ways which results in substantial improvement in electrical apparatus or machinery. The words 'electrical apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

ogy, to 14 in January 1954. This was followed by a 6-meeting course, "Magnetic Amplifiers," given by Professor A. Kusko, Massachusetts Institute of Technology, in March 1954 to 40 men. "Applications of Automatic Computing Machines" was offered in January 1954 to 24 by Professors Charles Adams, R. E. Scott, Linvill, and Verzuh, all of the Massachusetts Institute of Technology faculty.

Each person satisfactorily completing a course receives a certificate signed by the course instructor and the Boston Section chairman.

A number of other AIEE Sections also have been successfully conducting educational courses for a period of years which has proved to be a very valuable service to their members.

Illinois Technology Branch Celebrates Golden Anniversary

This year, the AIEE Student Branch at the Illinois Institute of Technology celebrates its golden anniversary. Originally founded at the Armour Institute of Technology on February 26, 1904, the Armour Branch was consolidated with the Branch at Lewis Institute in 1941 when the two institutions joined to form the Illinois Institute of Technology.

On February 26, 1954, an anniversary dinner and reunion was held on the campus of the Illinois Institute of Technology which was attended not only by a large group of Student members, but also by representatives from the AIEE Chicago Section and from other Student Branches. The dinner was made possible through the financial aid of the AIEE Chicago Section which for many years has co-operated closely with Student Branches in the area.

Titus G. LeClair, past president of the AIEE, was main speaker of the evening. Others at the speakers' table included: C. M. Summers, incoming District vice-president; R. W. Jones, chairman of the Chicago Section; Frank Simon, chairman of the Section's Students and Young Engineers Committee; Eric T. B. Gross, chairman of the Great Lakes District Committee on Student Activities; A. H. Wing, counselor of the Northwestern University Student Branch; E. R. Whitehead, head of the electrical engineering department at Illinois Institute of Technology; J. D. St. John, representing the Milwaukee School of Engineering Student Branch; Roy Hovinen, chairman of the Northwestern University Student Branch; E. C. Duerr, president of Illinois Beta Chapter of Tau Beta Pi; John Miyasaki, president of Delta Chapter of Eta Kappa Nu; and E. E. Bahnmaier, president of Rho Epsilon and past Branch chairman. The speakers were introduced by the Branch chairman, J. R. White.

The meeting was attended by approximately 100 persons representing about an equal number of students and engineers.

Former officers with the present chairman of the Student Branch at the Illinois Institute of Technology, left to right: E. F. Koncel, F. R. Roubik, Chairman J. R. White, E. E. Bahnmaier

Missouri Mines Branch Inspects Hydro Plant

Forty-one members of the Joint AIEE–Institute of Radio Engineers Student Branch at the Missouri School of Mtnes and Metallurgy recently visited the Osage Hydro Plant of the Union Electric Company of Missouri.

This plant was completed with an installed capacity of 129,000 kw in 1931; its generating capacity recently was increased to 172,000 kw by the installation of two new generators. The students were conducted on a complete tour from the bottom level to the top of the dam which is a concrete structure rising 148 feet above bedrock and spanning 2,543 feet from abutment to abutment.

The trip is the fourth of a series of six planned by the Branch for this year.

EJC Reports Results of Survey of Engineers' Incomes in 1953

The Engineers Joint Council (EJC) has announced the publication of "Professional Income of Engineers—1953." This 32-page publication is the final report of a survey conducted in 1953 by the EJC Special Surveys Committee. Maynard M. Boring, General Electric Company, representing the American Society for Engineering Education on the committee, is chairman.

The report contains information covering the professional income of about 72,000 engineers employed in industry, government, and engineering education. This represents about 22 per cent of the total of engineers estimated to be employed by industry and engineering education. The basic presentation of data is in relation to year of receipt of first degree in engineering.

The income of engineers employed in in-

dustry is presented by type of industry in which employed. This is a departure from practices employed in earlier surveys which presented data by engineering specialties. EJC believes that presentation in this manner will prove to be more useful.

In engineering education, the information reflects total income from the practice of the profession of engineering as well as income from teaching activities alone. The summary of starting salaries offered during 1953 to new engineering graduates by type of industry is included also.

This report provides the most comprehensive study of engineering professional income since "The Engineering Profession in Transition" was published in 1947. As such, it will be of great interest and value to all concerned with questions of engineering income. The report is available from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y., at $2.00 per copy with a discount of 50 per cent for single copies to members of constituent societies of EJC.

F. V. Smith Addresses Oak Ridge Section

On March 31, 1954, Frank V. Smith of Sargent and Lundy, Engineers, Chicago, Ill., addressed the AIEE Oak Ridge Section on the subject, "Recent Developments in Electric Power Transmission." Mr. Smith is chairman of the AIEE Committee on Transmission and Distribution. Guests at the meeting were members of the East Tennessee Section and visitors from the engineering and operating offices of the Tennessee Valley Authority. Among those in attendance were, left to right: S. G. T. Arnold, director, Oak Ridge Section; W. H. Lee, vice-chairman, Oak Ridge Section; D. M. Clarke, assistant secretary-treasurer, Oak Ridge Section; F. V. Smith; R. B. Somers, chairman, Oak Ridge Section; C. P. Almon, Jr., Vice-President, District 4; and D. B. Janney and G. A. Holt, directors, Oak Ridge Section

Panel Discussion Summarized on Rectifier Substation Layout

To record some of the salient physical characteristics of a modern rectifier substation, the Electrochemical Processes Subcommittee of the AIEE Committee on Chemical, Electrochemical, and Electrothermal Applications has summarized a panel discussion of this subject.

Although many variations will exist depending upon local conditions, a basic arrangement for many large rectifier installations combines outdoor transformers and high-voltage structure with a 2-story building for indoor equipment. Transformer equipment is located along the length of the substation building. Usually high-voltage structure with disconnecting switches, fuses, instrument transformers, etc., is integrated with transformer space requirements. The inside of the building, the rectifier, and part or all of the switchgear is usually on the upper level with heat exchangers, batteries, station ventilating and other miscellaneous equipment, bus runs, and part of the d-c switchgear being located on the lower level.

Where single-story buildings are utilized, the transformer equipment and high-voltage switching and bus are normally located outdoors with the several units of a multiunit installation being side-by-side along the length of the building. For such installations, the indoor equipment is usually roughly aligned perpendicular to the length of the building with the anode switchgear being immediately inside of the wall and the rectifier spaced a reasonable distance from it for accessibility. The excitation cubicles are sometimes mounted on the end of the rectifier opposite from the anode circuit breaker. For other installations, they are mounted on the opposite wall where the cathode circuit breakers are also normally located. Centralized control is common; the location of the master control board varies according to the convenience or desirability of particular installations.

Some specific suggestions made are as follows:

1. The use of troughs for control cable runs rather than conduits greatly facilitates installation, maintenance, and upkeep of the equipment.
2. The use of vinyl tile on the floor reported by one user provides good insulation, and is justified by its low maintenance cost.
3. The extensive and successful use of aluminum for anode and d-c buswork in aluminum reduction plants is reported. It is also being used for high-voltage a-c buswork. Welded joints are practical. The main d-c bus is normally tapered depending upon the points at which the conversion equipment is connected to it and the points at which load is taken off.

Most users with large installed capacity have facilities for cleaning and repairing the rectifier tubes. This work is usually done in a small air-conditioned room.

Although cranes for handling the equipment are reported in some instances, the trend seems to be toward the use of dollies or trucks as the latter are cheaper than a crane installation.

Fire protection facilities vary greatly according to local conditions. Where these facilities are provided, water spray or barrier walls with fog nozzles are normally used.

Some plants report special attention to ventilation of buildings housing the rectifier equipment. Intake air is sometimes filtered through an oil-bath-type filter.

Water-to-water-type heat exchangers are used on the vast majority of large rectifier installations although a few report water-to-air-type exchangers with varying success.

Prize Paper Awards Presented at Akron Student Branch Meeting

A meeting of the Joint AIEE–Institute of Radio Engineers (IRE) Student Branch was held on March 9, 1954. This was the annual joint AIEE-IRE Branch and Section meeting with prize paper competition.

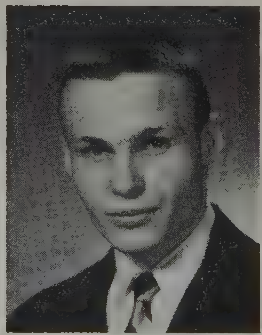
First prize was won by Don Corbett for his paper, "Trodi, Touchdown Rate on Descent Indicator." Second prize went to J. A. Wilson for his discussion of the "St. Lawrence Seaway." "Synchrotie Systems" by Robert Savoy won third place. G. A. Shiner was presented with the Outstanding Student Award by the IRE section.

Following the meeting, demonstration experiments were held in the school laboratories. These included the Eddy Current Dynamometer for fractional-horsepower motors which was built at the university.

The Branch chairman is Floyd Jean and B. C. Kent is secretary

Fortescue Fellowship Award Announced for Year 1954–55

The AIEE Charles LeGeyt Fortescue Fellowship Committee has awarded a fellowship for graduate study in electrical



W. L. Kilmer

IEC Golden Jubilee Plans

Members of the United States National Committee of the International Electrotechnical Commission (IEC) hear P. H. Chase report progress of plans for the IEC Golden Jubilee to be held at the University of Pennsylvania, September 1–16, 1954. Left to right (facing): E. F. Seaman, Department of the Navy, Bureau of Ships; Walter C. Wagner, Philadelphia Electric Company; A. A. Brainard, president, U.S. National Committee (USNC) of the International Commission on Illumination; P. H. Chase, Philadelphia Electric Company, chairman of the IEC Golden Jubilee General Committee; J. W. McNair, American Standards Association, secretary of the U.S. National Committee of IEC; R. C. Sogge, General Electric Company, president of the USNC; Vice Admiral George F. Hussey, Jr., U.S. Navy (Retired), American Standards Association, treasurer of the USNC; C. C. Chambers, vice-president, University of Pennsylvania; W. E. Caldwell, Consolidated Edison Company of New York; A. G. Christie, Johns Hopkins University; K. M. Irwin, Philadelphia Electric Company; J. S. Perribone, American Society for Testing Materials. Center (left to right): V. L. Cox, General Electric Company, Howard H. Weber, U.S. Rubber Company; L. G. Cumming, Institute of Radio Engineers, Axel G. Jensen, Bell Telephone Laboratories

engineering during the academic year 1954–55 to William L. Kilmer.

Mr. Kilmer, who is from Wellsboro, Pa., is a student at the Pennsylvania State University where he will receive his bachelor of science degree in electrical engineering this semester. He is a member of Tau Beta Pi, of which he has been president, Eta Kappa Nu, and other honorary fraternities.

Mr. Kilmer was employed by the Philadelphia Electric Company as a junior technical assistant during the summer of 1953. He will do graduate work at the Pennsylvania State University in the servomechanisms field.

The Fortescue Fellowship was established through a trust fund set up by the Westinghouse Electric Corporation in recognition of Mr. Fortescue's valuable contributions to the electric power industry and is administered by the AIEE.

Lynn Section Organizes New Maine Subsection

The Maine Subsection of the Institute was officially organized by the AIEE Lynn (Mass.) Section at a dinner meeting held at Hallowell, Maine, on April 7, 1954. More than 100 members and guests were in attendance.

The program included a talk by R. J. Coe, New England Power Company, entitled, "Atomic Energy Today and Tomorrow," and a showing of the General Electric Company film, "A Is for Atom." The following officers were elected and installed for the Maine Subsection: Chairman, B. T. Payne; Vice-Chairman, H. W. Murdock; Secretary-Treasurer, S. A. Hutchinson; Senior Member-at-Large, K. G. Crabtree; Junior Member-at-Large, C. E. Monty.

Regular meetings have been held at various locations in Maine since October 1953.

Officers of the new Maine Subsection, left to right: B. T. Payne, H. W. Murdock, C. E. Monty, K. G. Crabtree, S. A. Hutchinson

Washington Section Presents Farewell Gift to Henline

H. H. Henline, who is retiring as Secretary of the Institute, was guest of honor at a meeting of the AIEE Washington Section on April 13, 1954. As a token of appreciation for his services, the Section presented Mr. Henline with a wall barometer and thermometer set.

The presentation was made by the Section chairman, G. Gravatt Coleman, who expressed the Washington Section's thanks for Mr. Henline's help and advice in the past and the hope that he would continue to visit them unofficially in the future.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Television and Aural Broadcasting Systems (*C. E. Dean, Chairman; L. M. Rodgers, Vice-Chairman; R. K. Hellmann, Secretary*). The rapid progress of color television, which was accented by the adoption of national standards by the Federal Communications Commission in December 1953 has been fully recognized by the committee and interesting papers on the subject were arranged at the Winter General Meeting in January. Further coverage is planned for the Summer and Pacific Meeting to be held in June.

Another field in which rapid advances are occurring is magnetic recording, and plans are being made for technical papers on this subject at the Fall General Meeting this coming October.

The committee started on a new activity recently, the outlining of a suitable television program in the "Creative Frontier" series planned to acquaint the public with important technical developments. The successful introduction of color television was chosen as a recent and dramatic instance of this, an improvement requiring years of research and development.

General Applications Division

Committee on Air Transportation (*W. L. Berry, Chairman; L. R. Larson, Vice-Chairman; P. Duyan, Jr., Secretary*). The Annual Aircraft Electric Equipment Conference will be held at the Fall General Meeting in Chicago, Ill., October 15–21, 1954. The Subcommittee on Rating of Air-borne Electric Apparatus plans to devote one session at the conference to the thermal rating of rotating equipment.

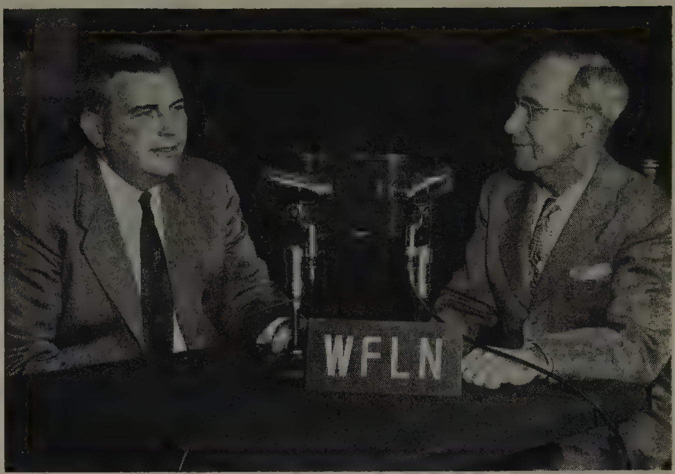
The Subcommittee on Aircraft Electri

Rotating Machinery recently completed two test codes. AIEE Test Code No. *800*, "D-C Aircraft Rotating Machines," is being published as an official test code. The test code on "400-Cps A-C Machines" has been submitted to the Committee on Air Transportation for approval.

The Subcommittee on Aircraft Electric Systems has recommended to the Standards Committee that the nominal system voltages of 14 and 28 volts direct current be specified in AIEE No. *700* since 12 and 24 volts direct current (as now specified) is inconsistent with current aircraft practice.

The Subcommittee on Aircraft Control, Protective Devices, and Cables has completed two test codes. AIEE Test Code No. *801*, "Aircraft Circuit Interrupting Devices," has been submitted for final publication. The test code on "Carbon Pile Voltage Regulators" has been submitted for 1-year trial publication.

Philadelphia Section Broadcast



Dr. Carl C. Chambers, of the University of Pennsylvania, was guest speaker on the April 21 "Meet the Engineer" broadcast, sponsored by the AIEE Philadelphia Section. Dr. Chambers, who discussed "Engineering Education for Nonengineering Employment," left, with T. H. MacCauley of the Radio Committee

Power Division

AIEE Committee on Carrier Current (*S. G. Leyland, Chairman; L. G. Eaton, Vice-Chairman (East); L. E. Ludekens, Vice-Chairman (West); H. W. Lensner, Secretary*). A symposium on microwave is being planned for the 1954 Fall General Meeting in Chicago, in view of the high interest shown in a similar activity at the 1953 Pacific General Meeting in Vancouver. This will be in addition to a regular technical session to be held at the meeting.

Subcommittee activity at the present time is being concentrated on two important subjects: (1) methods of measurement of high-frequency characteristics of power and carrier equipment, and (2) standards for carrier radiation.

Committee on Insulated Conductors (*M. H. McGrath, Chairman; M. W. Ghen, Vice-Chairman; L. E. Fogg, Secretary*). A 2-day meeting of the committee, consisting of individual meetings of the various subcommittees on the first day and a general meeting of the entire committee on the second day, was held in St. Louis, Mo., April 20–21, 1954. Many important projects are under study by the various subcommittees as shown in the following

Standards and Publications Subcommittee. Tabulation and classification work on the "Classified Bibliography of Insulated Conductors," a bibliography of important technical articles on insulated conductors published in English over the past 20 years or so, is nearing completion and tentative plans are being studied for its publication and for issuance of yearly supplements to keep the publication up to date.

Cable Characteristics Subcommittee. Studies continue on a number of important projects such as the observed instability of the thermal resistivity of the soil in some locations under certain conditions which appear to be related to the soil type and to moisture migration characteristics; the effect of weekly load factor on the load capability of buried and pipe-type cable systems; the hydraulic aspects (i.e., oil flow, pressure drop, etc.) of oil-filled pipe-type cable systems; and calculation and evaluation of the sheath losses encountered in multiconductor aluminum-sheathed power cable.

Cable Supply Systems Subcommittee. Plans are being made, in collaboration with a working group of the Accessories Subcommittee, for the presentation in the near future of a group of papers covering the fundamental requirements for the application of nonleaded cable to secondary distribution systems.

Science and Electronics Division

Committee on Magnetic Amplifiers (*E. V. Weir, Chairman; W. J. Dornhoefer, Vice-Chairman; H. W. Lord, Secretary*). This committee met during the 1954 Winter Meeting in New York City. At that time the committee dealt with an extensive reorganization of its subcommittees. This included abolishing the Subcommittee on Principle Groups, combining the Subcommittee on Test Codes with the Subcommittee on Standards, appointing a number of new members to several of the subcommittees, and appointing three new subcommittee chairmen to replace those who had resigned.

The committee plans to meet in Los Angeles, Calif., during the 1954 Summer and Pacific General Meeting. This will provide an opportunity for the newly organized West Coast Subcommittee to meet with the main committee.

The Subcommittee on Magnetic Materials met during the 1954 Winter Meeting. Core materials manufacturers had been invited to that meeting for joint discussion of the core properties measurement problems and methods.

The results of these discussions were to be used as a guide to future work of this subcommittee.

The Subcommittee on Theory also had met, just prior to the committee meeting, and decided that the magnetic core now appeared to be the element of magnetic amplifiers about which the least is known in a theoretical way. This subcommittee plans to review such core problems with the Subcommittee on Materials and to sponsor a session on this subject, possibly at the 1955 Winter General Meeting to be held in New York, N. Y., in January.

Committee on Metallic Rectifiers (*Glen Ramsey, Chairman; D. E. Trucksess, Vice-Chairman; E. A. Harty, Secretary*). The activities of the Committee on Metallic Rectifiers are expanding due to the increased interest in semiconductor devices and their growth from small circuit components into power devices covering a wide range in voltages and now are entering into the 1,000-ampere size. Germanium and silicon have joined with selenium, copper oxide, and sulfide in the metallic rectifier field.

Five new subcommittees have been added to the existing six subcommittees. New subcommittees are being organized covering semiconductor rectifying devices, germanium rectifiers, power rectifiers, and metallic rectifiers for magnetic amplifiers. In addition, a subcommittee was organized for publicity.

The Subcommittee on Technical Information is continuing its investigation of problems peculiar to metallic rectifiers such as the effects of pulse loading, temperature, peak currents, and harmonics on the ratings of the individual cells. The effects of chemical vapors, paint finishes, and oil immersion are being studied.

Test data are being collected on the effect of the operating current density and forward aging and the effect on the life of the cells. Records of failures in the field, with contributing causes, are being collected. These data will be published in a committee report.

A preliminary test code for metallic rectifying stacks was distributed for comments. This test code when completed will supplement the definitions and test code on rectifying equipment.

The Subcommittee on Patents has issued a 100-page compilation of patents on metallic rectifiers, listed first by subject and then by assignment. This report may be published later.

The committee has added new members who will be included into subcommittees. The liaison has been expended to include three societies and five other technical committes of the Institute.

AIEE FELLOWS ELECTED . .

Board of Directors Meeting, April 7, 1954

Ross D. Brown (AM '24, M '36), chief engineer, Monongahela Power Company, Fairmont, W. Va., has been transferred to the grade of Fellow in the AIEE "for his initiative in direction and engineering development of a statewide electric power system." Mr. Brown was born in Morgantown, W. Va., December 15, 1897, and was graduated from West Virginia University in 1922 with a bachelor of science degree in electrical engineering. After a few months with the General Electric Company, Schenectady, N. Y., he joined the Monongahela Power Company and predecessor companies and has been system operator, electrical engineer, and chief engineer. Some of the special engineering studies Mr. Brown has undertaken include the following: From 1926 to 1928 he applied three Klydonographs on a highly exposed H-frame 66-kv line over a period of three lightning seasons. This work pointed the way to improvements in electrical design and insulation co-ordination of wood-pole lines. From 1924 to 1937 he field tested relays by staging faults on the transmission system. These tests were effective in supplying clues to the source of undesired or improper operations of the protective system. Field tests of repeater fuses led to an understanding of the limitations of the device and assisted in its proper application. During 1946 to 1951 he served on Joint Subcommittee on Joint Use of Poles for Rural Power and Telephone Circuits under the Edison Electric Institute–Bell Telephone System Joint Committee on Plant Co-ordination. The subcommittee developed and submitted engineering specifications for long-span joint construction. Studies of effects of harmonics resulting from mine rectifier operation on local and Bell Telephone Systems have led to various designs and applications of filters to suppress harmonics propagated over an extensive 12-kv rural system. Mr. Brown is a member of Tau Beta Pi, Eta Kappa Nu, West Virginia Society of Professional Engineers, and National Society of Professional Engineers.

James DeKiep (M '43), vice-president, Electric Machinery Manufacturing Company, Minneapolis, Minn., has been transferred to the grade of Fellow in the AIEE "for his contributions to the development of electric generators and motors." Mr. DeKiep was born in Grand Haven, Mich., October 13, 1905, and was graduated from the University of Michigan in 1927 with a bachelor of science degree in electrical engineering. He joined the Westinghouse Electric Corporation after graduation as a student engineer, and in 1928 became a design engineer on induction motors. He became design engineer on wound-rotor, synchronous, and Navy induction motors in 1936. From 1942 to 1944 he was section manager, a-c motor section, in charge of all a-c motors and generators in the sizes handled by the motor engineering department. He was awarded the Westinghouse Order of Merit in 1943 for "the outstanding success of his work with the Navy Department in the development and expediting of equipment needed by our nation at war." He designed and tested the first silicone insulated motor in 1943. He served as manager, a-c motor engineering, from 1944 to 1945. In 1945 he joined the Electric Machinery Manufacturing Company as chief engineer in charge of all engineering and development. He was elected to the board of directors in 1947 and became vice-president in 1949. He received the Navy Commendation for his work during World War II and in October 1953 was cited by the University of Michigan as a "distinguished alumnus in recognition of his outstanding achievements and of his contributions to the development of the field of engineering." Mr. DeKiep is AIEE representative on the American Standards Association *C50* Committee and is serving on the Institute Committee on Rotating Machinery (1948–54).

James E. Dingman (M '37), vice-president and general manager, director, Bell Telephone Laboratories, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions both in technical work and in leadership of engineering groups in the field of communication." Mr. Dingman was born August 19, 1901, in Baltimore, Md., and was graduated from the University of Maryland with a bachelor of science degree in 1921. He became associated with the American Telephone and Telegraph Company in 1924 in New York City and worked in the long lines department on staff supervision of interstate telegraph and teletypewriter service. He was responsible, under supervision, for developing and preparing operating methods for large interstate teletypewriter and telegraph networks. In 1930 he became district plant superintendent in New Haven, Conn., in charge of long lines plant department operations and maintenance work in Connecticut. In 1933 he become division plant engineer, New York City, in charge of workers preparing detailed plans and cost estimates for long-distance telephone and telegraph outside plant and central station office equipment for interstate service. He was outside plant engineer from 1935 to 1937 and division plant superintendent in 1937. From 1941 to 1943 he served as plant extension engineer, becoming employee relations manager in 1943, assistant to general manager in 1949. From 1949 to 1952 he was associated with the Diamond State Telephone Company, Bell Telephone Company of Pennsylvania, Philadelphia, first as vice-president—personnel, and later as vice-president—operations. Since December 1952 he has been vice-president and general manager, director, Bell Telephone Laboratories, Inc., reporting directly to the president of the Laboratories and with responsibility for personnel and all staff operations, including legal, financial, and publication matters.

Louis N. Grier (AM '22, M '42), chief electrical engineer, Aluminum Company of America (Alcoa), Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE "for his contributions to the design and development of electric power supply systems in the aluminum industry and for improvements in the application of electric power to the fabrication of aluminum." Mr. Grier was born in Sewell, N. J., June 29, 1892, and was graduated from Rutgers University in 1915 with a bachelor of science degree in electrical engineering. After a brief period with T. A. Gillespie Company, Mr. Grier joined Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation) in 1915. Mr. Grier served with the U. S. Army during World War I. After discharge from the service, he was employed at the New Kensington, Pa., Works of Alcoa to perform electrical testing and general engineering. In 1923 he was

Ross D. Brown

James DeKiep

James E. Dingman

Louis N. Grier

Charles T. Hatcher

John V. L. Hogan

George R. Town

transferred to the central engineering office of Alcoa, in Pittsburgh. In 1946 he was made assistant chief electrical engineer and chief electrical engineer in 1953. Mr. Grier has worked continuously for the past 30 years to design and improve power generating facilities and the associated substations and transmission lines. During World War II he directed electrical engineering design and construction of seven large smelting plants which Alcoa was building for the government. Combined, these represented the application of more than 1,300,000 kw of single-anode mercury-arc rectifiers. Mr. Grier has developed the use of channel aluminum bus for a-c and d-c distribution and substation work. His "swinging" suspension of channel bus to reduce short-circuit stresses is a popular application. He has pioneered in the use of aluminum wire and conduit in industrial and commercial building. He has made large-scale applications and worked out many problems of insulation, temper, and termination for aluminum conductor. He has served as chairman, secretary, and treasurer of the AIEE Pittsburgh Section and on the Institute Committees on Industrial Power Systems (1946–49) and Mining and Metal Industry (1947–54).

Charles T. Hatcher (M '37), division engineer, Consolidated Edison Company of New York (N. Y.), Inc., has been transferred to the grade of Fellow in the AIEE "for service and leadership in research and engineering of electric power cables and their application." Mr. Hatcher was born in Chester, Va., October 4, 1897, and was graduated from the University of Virginia in 1920 with an electrical engineering degree. In 1922 he was employed by the United Electric Light and Power Company, New York City, as assistant engineer. He has been employed continuously since by this company and its successor companies, now the Consolidated Edison Company of New York, Inc. He was engaged in planning work, with particular emphasis on cable installations, from 1922 to 1929. In July 1933 he became division engineer of the Cable Division. From that time he has been in responsible charge of cable engineering and cable engineering administration for the system. The work has included the selection of cables for particular applications and the preparation and issuance of specifications for the design of all cables used on the system, both in generating stations and in the transmission and distribution system, over the entire voltage range of 600 volts, 15, 27, 45, 69, and 138 kv. He also has been responsible for the establishment of cable loading limits, for the development of means for mitigating sheath corrosion on underground cables and on buried piping systems, and for the preparation of standards and splice designs for use in the purchase of materials and as installation instructions for the construction forces. He has planned and supervised the installation of numerous submarine cable crossings in the waters around New York City and has been responsible for cable installations on viaducts and in tunnels. He was concerned actively in the development of vertical distribution systems in skyscraper buildings. He has pioneered in the application of low-pressure gas-filled cable. Mr. Hatcher also has assisted in the development of cable testing and fault location methods. He has presented several papers on various cable subjects. Mr. Hatcher has served on the following AIEE committees: Insulated Conductors (1947–53, Chairman, 1951–53); Power Division (1951–54); Award of Institute Prizes (1953–54); and as Liaison Representative on the Standards Committee (1951–53).

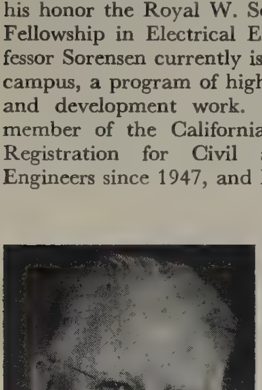
John V. L. Hogan (AM '11, M '20, Member for Life), president, Hogan Laboratories, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE "for his pioneer accomplishments in research, development, and engineering in the field of radio communication." Mr. Hogan was born in Philadelphia, Pa., February 14, 1890, and attended Sheffield Scientific School, Yale University. For 7 months during 1906 and 1907 he worked as a laboratory assistant to Dr. Lee de Forest, experimenting with the audion and radiophone. Mr. Hogan made the first quantitative study of the plate current characteristic of a grid triode. From 1910 to 1914 he served as telegraph engineer of the National Electric Signaling Company, both at Brant Rock, Mass., and Brooklyn, N. Y., where he supervised erection of the Bush Terminal station. In 1912 he was instrumental in the formation of the Institute of Radio Engineers (IRE). In 1913 he had charge of the acceptance tests of the U. S. Navy's first high-powered station at Arlington, Va., and became chief research engineer, 1914–17, with his work largely confined to development of automatic high-speed recorders for long-distance wireless. Appointed commercial manager of the International Signal Company in 1917, Mr. Hogan was put in charge of operations and manufacturing. In 1918 he was made manager of the International Radio Telegraph Company. Establishing his own consulting practice in 1921, he specialized in broadcasting apparatus and problems of radio regulation; in 1928 he added facsimile and television to his laboratory work. As a leader in work for tonal quality and realism in broadcasting, he built station *WQXR* as New York City's first high-fidelity station, and was among the first to operate an FM station in New York. During World War II he served as special assistant to director, Office of Scientific Research and Development. In 1947 he was awarded the Armstrong Medal by the Radio Club of America for outstanding contributions to the art, and in 1954 was awarded a citation by the Radio Pioneers. He is the author of several books and technical articles and has received 29 U. S. patents. He is a member of the Patent Compensation Board, U. S. Atomic Energy Commission. Mr. Hogan is a past president and fellow of the IRE, a fellow of the Acoustical Society of America, an honorary member of the Radio Club of America, and a member of the Society of American Military Engineers, Society of Motion Picture and Television Engineers, Armed Forces Communication Association, Yale Engineering Association, and American Institute of Physics. He has served on the following AIEE committees: Standards (1923–38); Communication (1947–48); and Telegraph Systems (1949–54).

George R. Town (AM '28, M '37), professor of electrical engineering and associate director, engineering experiment station, Iowa State College, Ames, has been transferred to the grade of Fellow in the AIEE "for contributions as an engineer, teacher, research administrator, and author in the field of radio and television." Dr. Town was born in Poultney, Vt., May 26, 1905, and was graduated from Rensselaer Polytechnic Institute in 1926 with an electrical engineering degree. He received the doctor of engineering degree from the same institution in 1929. From 1929 to 1933 he was a research engineer with Leeds and Northrup, Philadelphia, Pa., working on motor speed control, combustion control, and thyratron circuits. After a brief period with Arma Engineering Company, he was an instructor at Rensselaer Polytechnic Institute from 1933 to 1936. He joined Stromberg-Carlson Company, Rochester, N. Y., in 1936, serving first as an engineer in the research laboratory. During this time he worked on oscillator circuits, microphonics, audio amplifiers, development and design of television receivers. He was named engineer in charge of the television laboratory in 1940 and assistant director of research in 1941 in responsible charge of all high-frequency work—television, microwave, radar, radio communications. He became manager of engineering and research in 1944 and in addition became assistant secretary of the corporation in 1945. Since 1949 he has been associate director, engineering experiment station, and professor of electrical engineering, Iowa State College. He is responsible for all activities of the station and teaches courses and directs graduate research in electrical communications. He is alternate member of the

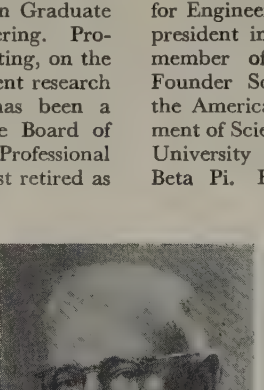
National Television System Committee and has served on other technical committees. Dr. Town is the author of several papers on television circuits and standards and FM allocations. He is a fellow and director of the Institute of Radio Engineers and a member of the American Society for Engineering Education, Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and Phi Kappa Phi. Dr. Town has served as chairman of the Rochester Section of the AIEE and is a member of the Committee on Television and Aural Broadcasting Systems of the Institute (1952–54).

AIEE PERSONALITIES.....

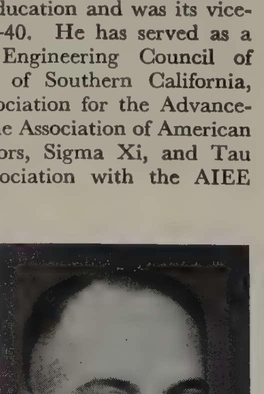
Royal Wasson Sorensen (AM '07, M '13, F '19, Member for Life), professor emeritus of electrical engineering, California Institute of Technology, Pasadena, has been elected an Honorary Member of the AIEE. Professor Sorensen will be presented the Honorary Membership Certificate at the Annual Meeting of the Institute, June 21, 1954, during the Summer and Pacific General Meeting at Los Angeles, Calif. Professor Sorensen was born in Wabaunsee County, Kans., April 28, 1882, and was graduated from the University of Colorado in 1905 with a bachelor of science degree in electrical engineering. He received the degree, electrical engineer, in 1928 and the honorary degree of doctor of science in 1938, both from the University of Colorado. Following his graduation in 1905, he entered the test course of the General Electric Company, Schenectady, N.Y. Upon completion of the test course, he was assigned to the transformer engineering department and in 1908 was transferred to Pittsfield, Mass. In 1910 he was invited to Pasadena to organize the electrical engineering department of Throop Polytechnic Institute (later California Institute of Technology). He started that work as associate professor and at the end of the first year was promoted to professor. He held that position and supervised the development of the electrical engineering department until 1950 when he was given the title of professor of electrical engineering emeritus and placed on a half-time schedule. For 2 years more he taught some courses. At the time of his appointment as professor emeritus, his former students established in his honor the Royal W. Sorensen Graduate Fellowship in Electrical Engineering. Professor Sorensen currently is directing, on the campus, a program of high-current research and development work. He has been a member of the California State Board of Registration for Civil and Professional Engineers since 1947, and has just retired as vice-president of that board. He is continuing the consulting practice which he started in 1913. In 1922 he originated in the United States the idea of cascade connections for high-voltage testing transformers. With Dr. R. A. Millikan, he developed a successful vacuum switch that has been used for aircraft and other light current circuits. He has been issued a number of patents relating to circuit interrupters. During World War I he was a member of a research team headed by Professor Harris J. Ryan engaged in the problem of studying submarine detection. During World War II he was first a co-ordinator for Engineering Science Management War Training courses in electrical engineering and then was associate director of a special studies group engaged in the development of aircraft torpedoes. For his aids to these programs, he received from the Armed Forces certificates of appreciation for exceptional service. In 1947 he was a member of a group of six scientists appointed by the National Academy of Science to visit Japan to make recommendations to the Japanese about the development of a modern program of technical education and the conduct of scientific and engineering research work to be done in educational institutions and industrial plants. In 1949 he was made an honorary member of the Institute of Electrical Engineers of Japan. Professor Sorensen holds the most valuable engineering service scroll of the Engineers and Architects Association of Los Angeles and was elected the first eminent member of Eta Kappa Nu. He has held offices in the American Society for Engineering Education and was its vice-president in 1939–40. He has served as a member of the Engineering Council of Founder Societies of Southern California, the American Association for the Advancement of Science, the Association of American University Professors, Sigma Xi, and Tau Beta Pi. His association with the AIEE began as an enrolled student in 1904. He has been secretary and chairman of the Los Angeles Section (1919–21), Student Branch counselor at California Institute of Technology (1930–33, 1935–36), secretary and chairman of the District 8 Committee on Student Activities (1926–27). A past president of the AIEE (1940–41), Professor Sorensen has served as a director (1936–40), vice-president, District 8 (1933–35), and on the following Institute committees: Research (1923–44, Chairman, 1941–43); Education (1924–28, 1934–37, 1939–40, 1943–49); Student Branches (1927–28, 1936–40, Chairman 1938–40); Instruments and Measurements (1927–30); Lamme Medal (1933–36); Edison Medal (1938–43); Planning and Co-ordination (1939–40); Executive (1940–43, Chairman, 1940–41); Membership (1939–40); Award of Institute Prizes (1941–43); Members-for-Life Fund (1944–54); Code of Principles of Professional Conduct (1947–54, Chairman, 1950–51); Registration of Engineers (1948–54); and Professional Division Advisory (1950–52). He has served as a member of the Institute team for College Curricula Accrediting of the Engineers' Council for Professional Development (1932–53).



Royal Wasson Sorensen



W. B. Morton



C. M. Laffoon

W. B. Morton (AM '25, F '42), station electrical engineer, Pennsylvania Power and Light Company, Allentown, has been named assistant electrical engineer of the utility. Mr. Morton was born in Dallas, Tex. After service with the U. S. Navy and experience as an electrician and foreman at the Mare Island, Calif., Navy Yard, Mr. Morton joined the Pacific Gas and Electric Company, San Francisco, Calif., as a draftsman. In 1925 he moved to Birmingham, Ala., as a drafting supervisor for the Dixie Construction Company. He moved to the Philadelphia Electric Company in 1931 as project engineer, becoming senior project engineer in 1932, and senior field engineer in 1940. He joined Pennsylvania Power and Light as station electrical engineer in 1945. Mr. Morton served as a commander in the U.S. Navy during War II. Mr. Morton is Vice-President, District 2, of the AIEE and also has served as a director and on many committees, including Sections, Membership, Technical Program, Transfers, Land Transportation, Marine Transportation, and Planning and Co-ordination. He is also a member of the Engineers Club of Philadelphia, a member and past president of the Affiliated Engineers Societies Council of Philadelphia, and the Engineers Club of the Lehigh Valley. He is affiliated also with the Illuminating Engineering Society, the Pennsylvania Electrical Association, the Pennsylvania Society of Professional Engineers, and the National Society of Professional Engineers.

C. M. Laffoon (AM '24, F '45), manager, a-c engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been presented with a Missouri Honor Award for Distinguished Service in Engineering by the University of Missouri. Mr. Laffoon was presented the award for his "notable achievements in the fields of engineering design and management; his

leadership in the development of large generators, synchronous condensers, and hydrogen cooling in generators; and his ability to understand his fellow men which has resulted in his assuming progressively greater responsibilities in one of the world's largest and best known manufacturing corporations." Mr. Laffoon was born on a ranch in Kansas in 1888. He attended Central Missouri State Teachers' College and then the University of Missouri, receiving the bachelor of science degree in electrical engineering in 1914 and a master of science degree in 1915. He joined the Westinghouse Company in their graduate engineering training course in 1916 and 2 years later entered the field of design engineering for that firm, gaining experience and responsibility in various phases of the work. He has been successively manager of five of their design and engineering departments. In 1938, Mr. Laffoon received the Westinghouse Order of Merit and Silver Award Medal for "outstanding achievements in the fields of engineering, management and design." In 1949 he received the AIEE Lamme Medal for "outstanding contributions to design of electric machines, particularly large turbine generators and high-frequency generators." Mr. Laffoon is a former director of the AIEE (1942–47) and has served on the following Institute committees: Electrical Machinery (1934–37, 1938–45, Chairman, 1938–40); Board of Directors (1942–47); Technical Program (1938–40); Lamme Medal (1942–46); Edison Medal (1943–45); Power Generation (1943–47); Transmission and Distribution (1943–44); and Board of Examiners (1945–50).

L. M. Robertson (AM '27, F '45), chief electrical engineer, electrical engineering department, Public Service Company of Colorado, Denver, recently received the Gold Medal Award of the Colorado Engineering Council for distinguished engineering service. Mr. Robertson was born in Denver on January 20, 1900, and was graduated from the University of Colorado in 1922 with a bachelor of science degree in electrical engineering. He also holds the degrees of electrical engineer and master of science from the University of Colorado and a bachelor of laws degree from Westminster Law School. He has been with the Public Service Company of Colorado since 1922. He was in charge of the transmission and station engineering department from 1925 to 1948. From 1948 to 1952 he was assistant superintendent of hydroelectric production and transmission. He was named to his present position in 1952. Mr. Robertson has been active in the Rocky Mountain Electrical League and the Colorado Engineering Council. A former vice-president of the AIEE, Mr. Robertson has served on the following AIEE committees: Transmission and Distribution (1942–54); Electrical Machinery (1944–47); Education (1945–47); Registration of Engineers (1946–51, 1952–53); Switchgear (1952–54); and Sections (1953–54).

W. H. Sammis (AM '20, M '38), president, Ohio Edison Company, Akron, has been named recipient of the 1954 Egleston Medal, Columbia University's highest award "for distinguished engineering achievement." Mr. Sammis was born at Hempstead, N. Y., June 28, 1896, and was graduated from Columbia University in 1917 with a degree in electrical engineering. Following his graduation he became a machinist and ensign in the U. S. Navy, serving as an instructor at the naval training school at Great Lakes, Ill. After serving one year as an instructor at Columbia University, New York, N. Y., he became a member of the Consumers Power Company, Jackson, Mich., in 1920, and 6 months later was made assistant electrical engineer, subsequently becoming power sales engineer. In 1924 he became affiliated with C. H. Tenney and Company, Boston, Mass. The following year he returned to the Consumers Power Company as assistant to the general manager, and in 1929 became assistant to the president. In 1932 he was made a vice-president and director of the company and was elected president of the Pennsylvania Power Company in 1936. He then became assistant to the vice-president and then vice-president of Commonwealth and Southern Corporation, New York, N. Y. He became president of Ohio Edison in 1944. Mr. Sammis is now serving as president of the Edison Electric Institute.

C. T. Shoch (M '48), assistant to the vice-president, commercial department, Pennsylvania Power and Light Company, Allentown, has been elected president of the National Society of Professional Engineers for 1954–55. A graduate of Drexel Institute of Technology, Mr. Shoch has been with Pennsylvania Power and Light since 1924, except for a 5-year period spent as a consulting engineer. **R. J. Rhinehart** (AM '49, M '50), division superintendent, Arkansas Power and Light Company, Pine Bluff, has been elected a vice-president representing the southwestern area.

J. C. Strasbourger (AM '31, M '40), general supervisor—mechanical buying, Cleveland (Ohio) Electric Illuminating Company, has been named chairman of the Membership and Professional Division of the Cleveland Engineering Center Building and Development Fund Campaign. Mr. Strasbourger is a Director and former vice-president of the AIEE and is a member of the Cleveland Engineering Society and the Engineers Club of New York. A graduate of the University of Cincinnati, Mr. Strasbourger has been with Cleveland Electric Illuminating since 1929. In addition to his bachelor of science degree in electrical engineering, he also holds a bachelor of laws degree from Cleveland Law School.

D. C. Herrick (AM '16, M '42, Member for Life), manager, plant engineering department, Lamp Division, General Electric Company, Cleveland, Ohio, retired March 31, 1954. Mr. Herrick, a native of northern Ohio, is a graduate of Case Institute of Technology, holding a bachelor of science degree in electrical engineering. He joined General Electric in 1912 in what is now the Lamp Division. He transferred to the plant engineering department at Nela Park in 1919 and became manager of the department in 1947.

S. I. Lindell (AM '26), chief engineer, S and C Electric Company, Chicago, Ill., has been appointed vice-president—engineering. Mr. Lindell, who began with the company in 1925, has served in the capacities of design engineer, development engineer, assistant chief engineer, and chief engineer.

R. L. Opper (AM '50), electrical engineer, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, and **R. E. Harrison** (AM '49), electrical engineer, United States Naval Ordnance Plant, Indianapolis, Ind., have joined the Midwest Research Institute, Kansas City, Mo., as an electrical engineer and a senior project engineer, respectively.

W. J. Lewis (AM '48, M '50), assistant chief engineer, Ohio Brass Company, Mansfield, has been appointed chief engineer of the Mansfield Plant. Mr. Lewis joined the Ohio Brass Company in 1941. Before that time he was associated with the Cincinnati (Ohio) Street Railway Company, and later the R. Roy Holden Company, Chicago, Ill., where he was vice-president. Mr. Lewis is a graduate of the University of Cincinnati and is a member of the Ohio Society of Professional Engineers.

J. M. Staton (AM '50), Flores de El Salvador and Ables and Company, San Salvador, El Salvador, has been appointed to the staff of the Y-12 Plant, an atomic energy installation operated by Carbide and Carbon Chemicals Corporation at Oak Ridge, Tenn.

A. M. Harrison (M '46), manager, transportation engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named manager of the Transportation and Generator Division engineering department. Mr. Harrison joined Westinghouse in 1926, following his graduation from Carnegie Institute of Technology. In 1945 he was made section manager of the d-c engineering department and was appointed manager of this department in 1950. He was named manager of the Transportation and Generator Division transporation engineering department in 1952. Mr. Harrison has served on the AIEE Committees on Student Branches (1947–48); Rotating Machinery (1951–53); and Land Transportation (1953–54).

N. F. Diederich (AM '45, M '52), manager of engineering standards, Clark Controller Company, Cleveland, Ohio, has joined the Electric Products Company, Cleveland, as manager of engineering. After graduating from Case Institute of Technology in 1932 with a bachelor of science degree in electrical engineering, Mr. Diederich spent 17 years with the Clark Controller Company. He is a registered engineer in Ohio and has been active in the Cleveland Section of the AIEE.

W. P. Molette, Jr. (AM '46), sales engineer, General Electric Company, Richmond, Va., has been named manager—electric utility sales for the company's Richmond apparatus sales office. Mr. Molette joined General Electric in 1928 following his graduation

from Alabama Polytechnic Institute. He had assignments in central station sales in Schenectady, N. Y., and in the Philadelphia, Pa., office. Since 1937 he has handled central station sales both in Charlottesville, Va., and in Richmond.

G. W. Downs (M '44), chief engineer, William Miller Instruments, Inc., Pasadena, Calif., has been appointed vice-president and chief engineer. **J. F. Kalbach** (AM '37, M '44), has been named development engineer. Mr. Downs, who attended California Institute of Technology, has been with William Miller Instruments, Inc., since 1939. He has served on the AIEE Committee on Instruments and Measurements (1950–51).

J. J. Clarkson (M '49), engineering manager, fractional horsepower motor department, General Electric Company, Fort Wayne, Ind., has been appointed manager of the newly established specialty component motor department at Fort Wayne. Mr. Clarkson was graduated from the University of Alabama with a bachelor of science degree in electrical engineering in 1929 and joined General Electric that same year.

R. W. Snyder (AM '36, M '52), assistant division engineer, fractional horsepower motor department, General Electric Company, Fort Wayne, Ind., has been named manager of engineering of the hermetic motor department, Fort Wayne. **L. L. Ray** (AM '44, M '52), General Electric Company, De Kalb, Ill., has been appointed manager of engineering for the appliance motor department in De Kalb. **I. E. Ross** (M '44) and **H. B. Carter** (AM '37, M '48), both with the fractional horsepower motor department, Fort Wayne, have been named manager of engineering and manager of advanced engineering development, respectively, of the specialty component motor department, Fort Wayne.

L. P. Schaefer (AM '36, M '46), head, engineering department, Hinchman Corporation, Detroit, Mich., has been appointed secretary of the corporation. Mr. Schaefer is a graduate of Ohio State University and also did postgraduate work at the University of Illinois. He is a member of Eta Kappa Nu, the National Association of Corrosion Engineers, the Engineering Society of Detroit, Michigan Society of Professional Engineers, and National Society of Professional Engineers.

W. H. Martin (AM '14, F '30, Member for Life), vice-president in charge of station apparatus and outside plant development, quality assurance, and design engineering, Bell Telephone Laboratories, Murray Hill, N. J., has resigned to become Deputy Assistant Secretary of Defense (Applications Engineering). Mr. Martin has served on the AIEE Committee on Standards (1925–33).

E. J. Horlik, Jr. (AM '48), sales representative, Whitney Blake Company, Hamden, Conn., has been appointed field supervisor and will serve as a liaison between the New Haven, Conn., office of the company and the company's sales representatives. Mr. Horlik is a graduate of Rensselaer Polytechnic Institute and had previously been a sales engineer in the wire and cable division of United States Rubber Company.

C. H. Fritz (AM '48), electrical engineer, Shallcross Manufacturing Company, Collingdale, Pa., has been appointed assistant sales manager. Mr. Fritz has been associated with the engineering and sales departments of Shallcross for the past 7 years.

E. R. Moore (M '40), chief engineer, engineering department, Detroit (Mich.) Edison Company, has been named assistant manager of engineering. **W. E. Losie** (M '46), staff supervising engineer, engineering department, has been appointed assistant director, engineering co-ordination and services department. **W. F. Wetmore** (AM '36, M '43), chief electrical engineer, engineering department, and **H. C. Reasoner** (AM '53), operating engineer of power plants, production department, have been named director and assistant director, respectively, of the planning and project engineering department. Mr. Wetmore is serving on the AIEE Committees on Power Generation and Switchgear.

E. F. Bentley (M '49), assistant chief engineer, and **J. H. Nicholas** (AM '39), electrical engineer, G and W Electric Specialty Company, Chicago, Ill., have been named general manager and chief engineer, respectively. Mr. Bentley has been associated with G and W Electric Specialty since 1923. Starting in the engineering department as a draftsman, he has served successively as designer, project engineer, chief draftsman, and assistant chief engineer. Mr. Nicholas, a graduate of Purdue University, spent 3 years at the High-Voltage Laboratory, Ohio Brass Company, as a laboratory engineer before entering the employ of G and W in a similar capacity. In 1948 he was advanced to electrical engineer. Mr. Nicholas is serving on the AIEE Committee on Insulated Conductors.

W. H. Ruese (M '36), Marley Company, Inc., Kansas City, Mo., has been appointed superintendent of electrical operations, Ohio Valley Electric Corporation, Portsmouth. A native of Ohio, Mr. Ruese started in the electrical utility industry with the Miami Valley Electric Company, Sidney, Ohio, in 1918. In 1923 he joined that firm's then parent company, the Kansas Electric Power Company, Emporia. He was transferred to Lawrence, Kans., in 1926 and rose by 1934 to vice-president in charge of engineering and operations. He also was a director of the company. He held these positions until the company was merged with the Kansas Power and Light Company in 1949. Mr. Ruese was graduated from Purdue University in 1923.

R. P. Brown (AM '10, M '13, Member for Life), retired, chairman of the board, Brown Instruments Division, Minneapolis-Honeywell Regulator Company, Philadelphia, Pa., has been elected to Eta Kappa Nu by the Drexel Institute of Technology chapter for his "outstanding contributions in the electric field."

Walter Evan-Jones (AM '46), assistant to chief mechanical engineer, Conversion Division, Canadian Comstock Company, Ltd., St. Catharines, Ont., Canada, has become Ontario supervisor for broadcast and mobile radio equipments, Commercial Products Division, Canadian Marconi Company.

D. R. Daykin (AM '50), design engineer, International Business Machines Corporation, Endicott, N. Y., has been named technical engineer in time equipment engineering. Mr. Daykin has been associated with the company since 1951. A native of Cleveland, Ohio, Mr. Daykin received his bachelor of science degree in electrical engineering in 1947 from Case Institute of Technology. He is a member of the Institute of Radio Engineers, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

L. E. Caldwell (AM '42), senior electrical supervisor, Creole Petroleum Corporation, Cabimas, Venezuela, has transferred to the Esso Engineering Department, Standard Oil Development Company, Linden, N. J. Mr. Caldwell is a graduate of the Polytechnic Institute of Puerto Rico with a bachelor of arts degree and the University of Texas with a bachelor of science degree in electrical engineering. Since graduating, Mr. Caldwell has spent 3 years with the Humble Oil and Refining Company and nearly 15 years with Creole Petroleum Corporation.

R. W. Tolles (AM '39), maintenance superintendent, Stanley Works, New Britain, Conn., has been named plant engineer. Mr. Tolles joined the electrical department of the Stanley Works in 1939 and was transferred to the Electric Tool Division in 1941. During World War II he served in the U. S. Navy. Returning to the Stanley Works, he was made assistant power engineer in 1949 and 3 years later became maintenance superintendent of the Stanley Works. He also served as general superintendent of the Farmington River Power Company, a subsidiary of Stanley, and was elected to its board of directors. Mr. Tolles was graduated from the University of New Hampshire.

F. M. McKenna (AM '50), field engineer, Line Material Company, Dallas, Tex., has been named apparatus engineer in the Southwest Division operating out of Dallas. Mr. McKenna received a bachelor of science degree in engineering from Texas Agricultural and Mechanical College in 1939 and spent the next 10 years in the utility field. He has been with Line Material since 1949.

Frederic Attwood (M '27), vice-president in charge of eastern territory, Ohio Brass Company, New York, N. Y., retired May 1, 1954. Mr. Attwood joined the company in 1920 as general European agent and in 1927 was elected to the post of vice-president and

named a director of the company. He is president of the U. S. National Committee of the International Conference on Large High Tension Electrical Systems (CIGRE) and a member of the U. S. National Committees of the International Electrotechnical Commission and the World Power Conference. Although Mr. Attwood is withdrawing from active duties with the company, he will continue to serve as vice-president and director.

C. F. Kucera (M '46), assistant sales manager, switchgear department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed regional representative for transmission equipment in the Southeast regional office, Atlanta, Ga. Mr. Kucera has been with Allis-Chalmers since 1946. He served in the U. S. Navy from 1942 to 1946. Prior to that he was employed successively by the Interstate Power Company, Washington Water Power Company, and the Bonneville Power Administration. He is serving on the AIEE Committee on Substations (1953–54).

D. C. Luce (AM '36, F '49), vice-president in charge of combined operations, Public Service Electric and Gas Company, Newark, N. J., has been elected president of the company. Mr. Luce has been vice-president in charge of combined operations, a director, and member of the executive committee of the board of directors since March 1950. Previously he had been vice-president in charge of electric operation and prior to that, for 6 years, general manager of the electric department. He started with Public Service in 1924 as a cadet engineer in the electric department. Mr. Luce is a graduate of Lehigh University.

J. A. Witter (AM '52), technical engineer, International Business Machines, Endicott, N. Y., has been appointed test project engineer in the testing laboratory. Mr. Witter joined the company in 1935 as a student customer engineer in the International Business Machines School in Endicott, and after completing his training was assigned to the Pittsburgh, Pa., office. He later completed special courses in the school and in 1942 became a field supervisor in Pittsburgh. Mr. Witter returned to Endicott in 1947 as an instructor in the Customer Engineering School and in 1946 was made a technical engineer in the testing laboratory.

R. S. Wiseman (AM '49), has joined the Corps of Engineers Research and Development Laboratories, Fort Belvoir, Va., as chief of the research and photometric section of the electrical engineering department's night vision equipment branch. Dr. Wiseman recently received his doctorate from the University of Illinois. He received his bachelor of science degree from Illinois in 1948 and his masters in 1950. From 1948 to 1951 he was assistant professor of electrical engineering at Mississippi State College, State College. He is a member of the Illuminating Engineering Society, Optical Society of America, American Society for Engineering Education, American Institute of Physics, Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and Pi Mu Epsilon.

R. B. Bross (AM '44), manager, electromagnetic engineering section, Instrumentation Laboratory, Massachusetts Institute of Technology, Cambridge, has resigned to devote full time to consulting engineering in Natick, Mass. Mr. Bross graduated from Massachusetts Institute of Technology in 1939 and worked at the Universal Winding Company, Providence, R. I., until 1942. During the next 5 years he worked at the Diehl Manufacturing Company in New Jersey. In 1947 he joined the staff of Massachusetts Institute of Technology.

H. O. Wood (AM '43), engineering department, Philco Corporation, Philadelphia, Pa., has been appointed chief engineer, Television Division. Mr. Wood has been in charge of Philco television receiver design since 1951. He recently was appointed chairman of the television receiver committee of the Radio-Electronics-Television Manufacturers' Association.

I. F. Matthysse (AM '48, M '52), chief design engineer, Burndy Engineering Company, Inc., Norwalk, Conn., and **W. F. Bonwitt** (M '49), chief planning engineer, have been appointed assistant chief engineer and chief administrative engineer, respectively. A graduate of New York University, Mr. Matthysse was in the engineering department of Burndy for 25 years, during which he has been engaged in the design of electric conductors and cable limiters. He has received 14 patents. Dr. Bonwitt, who received a doctorate in physics at the University of Vienna, joined Burndy in 1938. He is a member of the American Society for Testing Materials.

J. G. Fleming (AM '37, M '45), research engineer, Bristol Company, Waterbury, Conn., has been appointed product planning manager. Mr. Fleming has served on the AIEE Committee on Electric Heating (1951–53).

C. L. Stroup (AM '29, M '45), chief engineer, Hubbard and Company, Chicago, Ill., has been made vice-president in charge of engineering. His headquarters will continue to be at the Chicago plant. A graduate of Louisiana State University, he worked for a large power company and later for an insulator manufacturer before coming to Hubbard and Company in 1940.

Roland Whitehurst (AM '20, F '43), vice-president and director, Electric Storage Battery Company, and general manager, Exide Industrial Division, Philadelphia, Pa., has been elected a director of the Materials Handling Institute, representing the electrical accessories industries. Born in Manchester, England, Mr. Whitehurst emigrated to the United States as a boy. He joined Exide in 1908 as an office boy in the New York, N. Y., branch. After holding positions of increasing responsibility he was appointed manager of the Washington, D. C., branch in 1920 and was transferred to the company's general offices in Philadelphia in 1940 as assistant general sales manager. In 1942 he became general sales manager and in 1948 vice-president in charge of sales. He was elected to the board of directors in 1951. Mr. Whitehurst is a member of the Society of Automotive Engineers and the Franklin Institute and has served on the AIEE Board of Examiners (1950–52).

J. M. Adair (AM '45, M '51), sales manager, Star-Kimble Motor Division, Miehle Press and Manufacturing Company, Bloomfield, N. J., has been appointed sales manager, Electric Motor Division, Hoover Company, North Plainfield, N. J. Mr. Adair has had more than 25 years' experience in the motor industry.

L. G. Walker (AM '53, M '53), chief systems engineer, Communications and Electronics Division, Motorola, Inc., Chicago, Ill., has been appointed power utility product engineer and acting product manager. Before joining Motorola in 1951, he was electrical engineer for Idaho Power Company, Boise. Mr. Walker is a graduate of the University of Utah and is a member of the Institute of Radio Engineers and the National Society of Professional Engineers. He is serving on the AIEE Committee on Carrier Current (1953–54).

E. R. Behn (AM '33, M '46), project supervisor, Walter Dorwin Teague Associates, New York, N. Y., has been appointed staff assistant to the manager of the electronics department at the W. L. Maxson Corporation, New York, N. Y. Born in Brooklyn, N. Y., on May 25, 1911, Mr. Behn received his bachelor of science degree in electrical engineering from Cooper Union in 1932. After obtaining a masters degree from the Polytechnic Institute of Brooklyn in 1937, he acquired a bachelor of laws degree in 1942 from George Washington University. Before joining Maxson, Mr. Behn was a project supervisor with Walter Dorwin Teague Associates for 4 years. Previously he was a senior development engineer with Control Instrument Company, Brooklyn, which followed 7 years with the U. S. Navy Bureau of Ordnance, Washington, D. C., as a senior electrical engineer. Mr. Behn is serving on the AIEE Committee on Feedback Control Systems.

OBITUARIES ....

Numan Reid Stansel (AM '03, M '35, F '45, Member for Life), retired, General Electric Company, Schenectady, N. Y., died March 24, 1954, at Lumberton, N. C. Mr. Stansel retired from the Industrial Engineering Division, General Electric, in 1946 after 36 years of service. Born in Robeson County, N. C., March 27, 1877, Mr. Stansel was graduated from North Carolina State College in 1898 with a bachelor of science degree. He subsequently received the electrical engineer degree from North Carolina State College in 1901 and the master of mechanical engineering degree from Cornell University in 1903. He served as instructor in electrical engineering at North Carolina State College, Raleigh, from 1898 to 1901 and as yard elec-

trician, U. S. Navy Yard, Norfolk, Va., 1903 to 1907. After serving as engineering inspector, U. S. Treasury Department, from 1907 to 1910, he joined the General Electric Company in 1910. In 1913 he was made manager of the El Paso, Tex., office of the company. In 1923 he was transferred to the Industrial Engineering Division, Schenectady, where until his retirement in 1946 he was engaged in electrochemical and electrometallurgical problems, particularly those involving industrial heating. He was the author of two books, "Industrial Electric Heating" and "Induction Heating," and numerous technical articles. He was a registered professional engineer and a member of the Electrochemical Society and Sigma Xi. He had served on the following AIEE committees: General Power Applications (1929–30); Electrochemistry and Electrometallurgy (1930–46, Chairman 1934–36); and Technical Program (1934–36).

Vernon Bailey Wilfley (AM '26, M '37), southwestern regional engineering manager, Westinghouse Electric Corporation, St. Louis, Mo., died April 6, 1954. Mr. Wilfley was born in Clarinda, Iowa, December 11, 1897. He enrolled in the State University of New Mexico in 1916, and in 1917 was called into military service in the U. S. Navy as a radio operator. After serving $2^1/_2$ years in the Navy, Mr. Wilfley resumed his studies at the State University of New Mexico and graduated in 1923 with a bachelor of science degree in electrical engineering. He joined the Westinghouse Graduate Student Course the same year. From 1924 to 1926 Mr. Wilfley was a central station engineer at the Westinghouse East Pittsburgh (Pa.) Works. From 1926 to 1930 he was assigned to the Seattle, Wash., office as a district engineer. In 1930 he established the engineering department in the Portland, Oreg., office. He was transferred to the St. Louis office in 1943 as a consulting and application engineer and was promoted to engineering supervisor in 1946. In January 1953 Mr. Wilfley was named southwestern regional engineering manager. Mr. Wilfley was an active member of the AIEE, having served as secretary and chairman of the Portland Section, District secretary of District 9, treasurer and secretary of the St. Louis Section, and on the Committees on Power Generation (1952–54) and Membership (1952–54). He was a registered professional engineer in Missouri.

Gerald George Burford (M '48), deputy chief engineer, Merseyside and North Wales Electricity Board, Liverpool, England, died March 22, 1954. Mr. Burford was born in Hertford, England, August 22, 1898, and received his technical training at Battersea Polytechnic, where he was awarded the Wells Gold Medal. From 1917 to 1919 he served in France. After further training with the British Thomson-Houston Company, Ltd., Rugby; Twiss Electric Transmission Company, Ltd., Stoke-on-Trent; and Siemens Brothers and Company, Ltd., Wollwich; he joined G. V. Twiss and Partners, London, in 1926. In 1932 he became senior assistant to the chief engineer of the British Power and Light Corporation, London. In 1940 the office was moved to Ringwood, Hampshire. He became personal assistant to the chief engineer, North Wales Power Company, Ltd., Wrexham, Denbighshire. At vesting date he was appointed assistant chief engineer at the Merseyside and North Wales Board, Liverpool, and became deputy chief engineer in 1952. Mr. Burford was a member of the Institution of Electrical Engineers.

Howard Raymond Harrison (AM '49), retired, General Electric Company, Switchgear and Control Division, Philadelphia, Pa., died February 23, 1954. Mr. Harrison was born in Schenectady, N. Y., June 4, 1893, and attended Union College and Johns Hopkins University. He had been with General Electric since 1917 and in 1929 transferred to the Philadelphia Works as design engineer for outdoor disconnecting switches. Prior to his retirement on January 1, 1954, he had been granted five patents and had presented several technical papers before the Institute.

MEMBERSHIP . . .

Recommended for Transfer

The Board of Examiners at its meeting of April 15, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Ayvasian, M. H., squad leader, Jackson & Moreland, Boston, Mass.
Bell, L. E., project chief electrical engineer, Atomic Energy Comm., Los Alamos, N. Mex.
Bhasin, O. P., executive engineer, Hydel Commercial Division, Roorkee, India
Bourne, H. C., Jr., assistant professor, Massachusetts Institute of Technology, Cambridge, Mass.
Brownell, H. S., senior distribution engineer, Alabama Power Co., Birmingham, Ala.
Butler, R. M., application engineer, General Electric Co., Schenectady, N. Y.
Carter, J. R., engineer, Jackson & Moreland, Boston, Mass.
Cheney, M. C., works manager, wire div., The Lewis Engineering Co., Naugatuck, Conn.
Claughton, J. C., Jr., engineer, Southwestern Public Service Co., Amarillo, Tex.
Cloud, R. W., d.i.c. staff, Massachusetts Institute of Technology, Cambridge, Mass.
Cogan, I., assistant professor, Drexel Institute of Technology, Philadelphia, Pa.
Cooke, S. C., Jr., application engineer, General Electric Co., Schenectady, N. Y.
Covey, A. B., special transmission facilities engineer, American Tel. & Tel. Co., New York, N. Y.
Craven, E. H., electrical engineer, Sandia Corp., Albuquerque, N. Mex.
Dahlberg, R. S., Jr., section engineer, Philco Corp., Philadelphia, Pa.
Danford, W. R., Jr., electrical engineer, Indiana & Michigan Electric Co., Fort Wayne, Ind.
Duncan, H. S., project engineer, Remington Rand, Inc., South Norwalk, Conn.
Eaton, L. G., assistant meter engineer, New England Power Service Co., Boston, Mass.
Esayian, C., electrical engineer, Bristol Engineering Corp., Bristol, Pa.
Fredrickson, J. J., engineer, General Electric Co., Jackson, Mich.
Frost, A. E., equipment research engineer, Western Union Telegraph Co., New York, N. Y.
Gordy, E. M., engineer, Consolidated Gas Electric Light & Power Co. of Baltimore, Md.
Hall, D. L., supervisory ordnance engineer, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.
Hansel, P. G., engineer-in-charge, radio engg. dept., Servo Corp. of America, New Hyde Park, N. Y.
Harshbarger, C. K., electrical engineer, Virginia Cellulose Div., Hercules Powder Co., Hopewell, Va.
Hart, W. E., field engineer, Westinghouse Electric Corp., Buffalo, N. Y.
Heise, L. R., manager, quotation & order service divs., General Electric Co., Baltimore, Md.
James, A. A., engineer of toll & crossbar equipment, Southern New England Tel. Co., New Haven, Conn.
James, H. E., supervisor of electrical installation, General Electric Co., Kansas City, Mo.
Jones, C. T., engineer, Southeastern Underwriters Association, Atlanta, Ga.
Keltz, E. L., Jr., sales manager, I-T-E Circuit Breaker Co., Philadelphia, Pa.
Krauss, H. L., associate professor of electrical engg., Dunham Laboratory, Yale University, New Haven, Conn.
Kroenert, J. T., branch head, U. S. Naval Underwater Sound Lab., New London, Conn.
LeVelle, A. S., senior engineer, Southwestern Bell Tel. Co., Dallas, Tex.
Lindstrom, T., consulting engineer, air arm div., Westinghouse Electric Corp., Baltimore, Md.
Lufkin, C. R., field engineer, General Electric Co., San Diego, Calif.
Lukey, J. G., construction supervisor, Commonwealth Edison Co., Chicago, Ill.
Maxwell, J. L., division engineer, Mississippi Power & Light Co., Jackson, Miss.
McAdie, C. H., design engineer, Westinghouse Electric Corp., Baltimore, Md.
McHenry, G. M., consumer service engineer, western region, Hydro Electric Power Commission, London, Ont., Canada
Meagher, A. W., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Middendorf, W. H. H., assistant professor of electrical engg., University of Cincinnati, Cincinnati, Ohio
Milliken, A. W., vice president & general manager, New York State Electric & Gas Corp., Binghamton, N. Y.
Montgomery, L. H., vice president, Metal Products Co., Nashville, Tenn.
Musil, J. D., electrical design engineer, Electric Machinery Mfg. Co., Minneapolis, Minn.
Naylor, H. E., Jr., electrical engineer, Ebasco Services, Inc., New York, N. Y.
Newman, T. J., owner, Meter Devices Co., Canton, Ohio
Nissley, R. R., engineering manager, New York City district, Westinghouse Electric Corp., New York, N. Y.
Oliver, J. M., vice president & general manager, Georgia Power Co., Atlanta, Ga.
Powers, R. A., head, meter service div., Boston Edison Co., Boston, Mass.
Rangel, R., treasurer, Sociedad Electro Mecanica, S. A., Mexico, D.F., Mexico
Rickley, A. L., supervisor, client service, Doble Engineering Co., Belmont, Mass.
Riley, G., engineer, Alabama Power Co., Birmingham, Ala.
Rueckert, J. J., assistant engineer, Consolidated Gas Electric Light & Power Co. of Baltimore, Md.
Russey, W. A., engineer, member of technical staff, Bell Telephone Laboratories, Murray Hill, N. J.
Saline, L. E., analyst, General Electric Co., Schenectady, N. Y.
Salzer, E., consultant & patent attorney, Chase-Shawmut Co., Newburyport, Mass.
Schwarz, F. S., electrical engineer, aviation armament lab., U. S. Naval Air Development Center, Johnsville, Pa.
Sherwood, R. W., superintendent of planning, Gulf States Utilities Co., Beaumont, Tex.
Smeloff, N. N., system planning engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Smith, H. R., substation engineer, Southern Engineering Co., Atlanta, Ga.
Sodergren, C. J., senior industrial engg. representative, Consolidated Gas Electric Light & Power Co. of Baltimore, Md.
Sponholtz, L. B., consulting & application engineer, Westinghouse Electric Corp., Washington, D. C.
Steelman, A. T., Jr., transmission engineer, Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Stephens, D. L., assistant engineer, Consolidated Gas Electric Light & Power Co. of Baltimore, Md.
Swanstrom, W. M., engineer, Public Service Co., Dixon, Ill.
Thompson, J. M., laboratory chief, Rome Air Development Center, Griffiss Air Force Base, N. Y.
Turner, H. G., engineer, The Pacific Tel. & Tel. Co., San Francisco, Calif.
Underwood, J. L., Jr., president, John L. Underwood Co., Inc., Atlanta, Ga.
Walling, F. E., principal electrical engineer, Mathieson Chemical Corp., Baltimore, Md.
Wartzok, D. F., supervising electrical engineer, Indiana & Michigan Electric Co., Fort Wayne, Ind.
Witkin, E., head, air-to-air fire control branch, Aviation Armament Laboratory, Johnsville, Pa.

72 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before June 25, 1954, or August 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Beranek, J. A., Columbia Broadcasting System, Inc., Los Angeles, Calif.
Gronan, J., Burns & Roe, Inc., New York, N. Y.
Guernsey, E. W., Consolidated Gas Electric Light & Power Co. of Baltimore, Md.
Horne, A. N., The Texas-Empire Pipe Line Co., Tulsa, Okla.
Kaufman, J., Diamond Ordnance Fuze Labs., Washington, D. C.

5 to grade of Member

OF CURRENT INTEREST

Solar Battery Converts Useful Amounts of Sun's Energy Directly Into Electricity

A solar battery, which converts light energy into electric energy with an efficiency of 6 per cent, was demonstrated recently at the Bell Telephone Laboratories, Murray Hill, N. J. This conversion efficiency compares favorably with that of gasoline and steam engines, in contrast with other photoelectric devices whose rating is about 1 per cent.

The solar battery simply consists of a series of thin strips of silicon, each a little longer and narrower than a razor blade. See Fig. 1. A microscopic layer of boron, 0.0001 inch thick, is introduced near the surface of the pure silicon, and it is at the silicon-boron interface that a transistor-like action occurs which results in a flow of current under the influence of light energy. These strips can be linked together electrically and can deliver power from the sun at the rate of 50 watts per square yard of surface.

Fig. 1. A solar battery that will convert the energy of the sun directly into electricity can deliver power from sunlight at the rate of 50 watts per square yard of surface

Developed by a 3-man team of scientists, G. L. Pearson, C. S. Fuller, and D. M. Chapin, physicist, chemist and electrical engineer respectively (see Fig. 2), the experimental solar battery with its present 6-per-cent efficiency can be improved to an efficiency of 10 per cent. The theoretical limit is 22 per cent. The scientists stated that as nothing is consumed or destroyed in the energy conversion process, and as the battery has no moving parts, it should last practically indefinitely.

At the demonstration, one of the solar batteries furnished the power for a telephone conversation over a short line and another the power to operate a portable FM transmitter, using transistors instead of tubes. The first-mentioned battery was energized by a high-powered electric lamp, but the transmitter's battery received the light directly from a heavily overcast sky, not direct sunlight as is shown in Fig. 3. It was stated that in full sunlight, the range of transmission of such a solar-battery-powered set would be about one mile.

Fig. 2. Inventors of the battery, G. L. Pearson, D. M. Chapin, and C. S. Fuller, are shown checking sample devices for the amount of electricity derived from sunlight, here simulated by a lamp

Fig. 3. The sun's rays falling on the solar battery are the only source of power needed to operate a small mobile radio transmitter. D. E. Thomas is using a pocket-sized radio transmitter containing transistors

Although work is still in the laboratory stage, actual use of the solar batteries in the telephone business is a strong possibility. They might be used as power supplies for low-

Future Meetings of Other Societies

American Institute of Chemical Engineers. National Meeting. June 20–25, 1954, University of Michigan, Ann Arbor, Mich.

American Management Association. General Management Conference. June 21–23, 1954, Hotel Statler, New York, N. Y.

American Society for Engineering Education. 62d Annual Meeting. June 14–18, 1954, University of Illinois, Urbana, Ill.

American Society for Quality Control. 8th National Convention. June 9–11, 1954, Kiel Auditorium, St. Louis, Mo.

American Society for Testing Materials. 57th Annual Meeting and 11th Exhibit of Testing and Scientific Apparatus and Laboratory Supplies. June 13–18, 1954, Hotel Sherman, Chicago, Ill.

American Society of Civil Engineers. June 14–19, 1954, Chalfonte-Haddon Hall, Atlantic City, N. J.

Association for Computing Machinery. Annual Meeting. June 23–25, 1954, University of Michigan, Ann Arbor, Mich.

British Institute of Radio Engineers. Convention on Industrial Electronics. July 8–12, 1954, Christ Church, University of Oxford, Oxford, Oxfordshire, England

Committee on Vacuum Techniques. High-Vacuum Symposium. June 16–18, 1954, Berkeley-Carteret Hotel, Asbury Park, N. J.

Edison Electric Institute. 22d Annual Convention. June 1–3, 1954, Atlantic City, N. J.

Institute of Radio Engineers—Professional Group on Communication Systems. Symposium on Global Communications. June 23–25, 1954, Washington, D. C.

Institute of the Aeronautical Sciences. Annual Summer Meeting. June 21–24, 1954, Institute of the Aeronautical Sciences Building, Los Angeles, Calif.

Interamerican Association of Sanitary Engineers. July 25–31, 1954, Sao Paulo, Brazil

International Union of Pure and Applied Physics. 8th General Assembly. July 6–9, 1954, London, England

International Union of Pure and Applied Physics and the Institute of Physics (Great Britain). Conference on Defects in Crystalline Solids. July 13–17, 1954, Bristol, England

National Society of Professional Engineers. 20th Annual Meeting. June 9–12, 1954, Schroeder Hotel, Milwaukee, Wis.

Pan-American Federation of Engineering Societies (UPADI). 3d Convention. August 2–12, 1954, Sao Paulo, Brazil

Radio-Electronics-Television Manufacturers Association. National Convention. June 15–17, 1954, Palmer House, Chicago, Ill.

Society of Automotive Engineers. Summer Meeting. June 6–11, 1954, The Ambassador, Atlantic City, N. J.

Society of the Plastics Industry. 1954 National Plastics Exposition and Technical Conference. June 7–10, 1954, Public Auditorium, Cleveland, Ohio

The American Society of Mechanical Engineers. Semiannual Meeting. June 20–24, 1954, William Penn Hotel, Pittsburgh, Pa.

World Power Conference. Sectional Meeting. July 25–August 10, 1954, Rio de Janeiro, Brazil

power mobile equipment or as sun-powered battery chargers which could be used at amplifier stations along a rural telephone system, such as that now under trial at Americus, Ga.

Among other silicon devices being studied at Bell Telephone Laboratories is a lightning protector for telephone lines which would be more compact and easier to maintain than those now in use. Also under study is a power rectifier for converting alternating into direct current. Both of these devices can operate at higher temperatures than other crystal rectifiers now in use.

Color Scanner and 19-Inch Picture Tube for Color Television Developed by Du Mont

Two new developments in the field of color television were demonstrated recently by the Allen B. Du Mont Laboratories, Inc. They were a "Color Multi-Scanner" for telecasting 16-mm color movies and still pictures and a 19-inch color picture tube, the Chroma-Sync Teletron.

The new Du Mont Color Multi-Scanner is an advance in equipment developed for telecasting 16-mm color movies and still pictures. It is the only equipment yet developed to present pictures, from 16-mm Kodachrome or its equivalent, which equal or exceed the over-all quality of "live" color pickup. The unit can improve the reproduction of the original film to provide the most pleasing color tones for the television viewer.

The Du Mont Color Multi-Scanner provides telecasters with a system for 16-mm color film pickup. It enables them to originate their own high-quality color programming in quantity from color film without the need for expensive color camera equipment. It is ideal for presentation of color advertising whether by film or color slides. It allows stations to use the majority of color film produced during the past 10 years. It provides smooth, simple operation with minimum operational requirements. The Color Multi-Scanner can produce pictures from monochrome films as well as color and it will allow broadcasters to present black-and-white programming until color programming is justified. Basically the unit is composed of three parts: 1. the flying spot scanner, 2. the color cinecon pickup units, 3. the color slide changer pickup unit.

Heart of the Color Multi-Scanner is the new *TA-188-A* scanner unit. This contains the cathode-ray tube, scanning generator, high-voltage supply, and an optically precise front-surface mirror for reflecting light from the cathode-ray tube to the color cinecons or the slide changer unit.

The cathode-ray tube is a newly developed type which operates at high voltages and produces an extremely bright light source. The increase in light output over previous designs retains high resolution and enables the system to provide an output voltage which has high signal-to-noise characteristics. The tube has a high-quality, neutral density faceplate with 66-per-cent transmission. The gray faceplate greatly improves small area contrast and increases "crispness" of the picture by reducing halation. The flying spot scanning tube is positioned vertically with its face pointing upward. The mirror which directs the light is placed above the tube face.

The Color Multi-Scanner operates in the following manner: An extremely small electron spot (known as a flying spot) traces an unmodulated raster of high light intensity on the face of the cathode-ray tube. Light from this raster is directed to the front-surface mirror and reflected to the color cinecon units.

A cinecon resembles a compact movie projector. It contains the film reel supporting mechanism, a film gate, lens elements, and a sound head. Unlike a film projector, there is no projection lamp in the unit. In its place is a multiplier phototube which receives light from the scanning unit rather than transmitting light from a projection lamp. The light from the scanning unit is focused on the moving film through appropriate lenses. The light then passes through the moving film and is modulated by the varying density of the film. In place of an intermittent film-moving mechanism is a multifaced rotating prism, which as it rotates in synchronism with the steady, continuous movement of the film, creates a stationary light image which is picked up by the multiplier phototube.

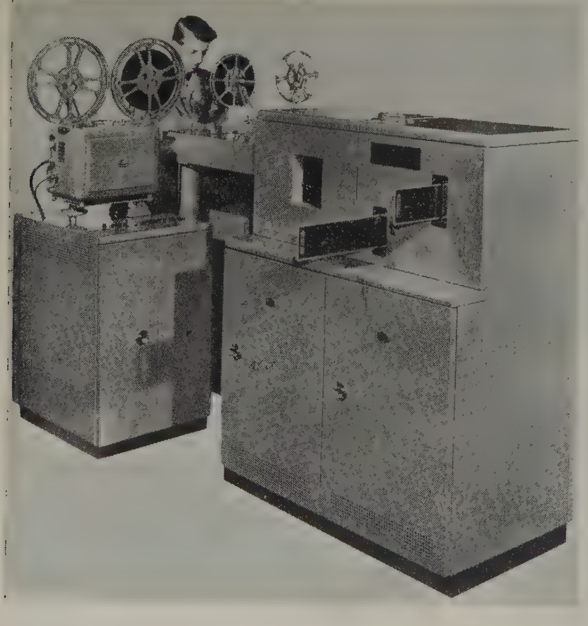
In the Color Multi-Scanner three of these tubes are used. The image is passed through dichroic (color selective) mirrors whereby the component colors of red, green, and blue are separated and caused to fall on the three separate multiplier phototubes.

The new Du Mont 19-inch Chroma-Sync color television picture tube with the mono-convergence tri-beam electron gun in the foreground

The multiplier tubes used in the cinecon are newly developed Du Mont 2-inch tubes which have the highest photocathode sensitivity and multiplier stability of any phototube now commercially available. Their sensitivity and stability also help reduce "noise."

The signals generated by the three multiplier phototubes then are passed through three video amplifiers, one for each color. The amplifiers correct for scanner tube phosphor characteristics and film gamma. Three simultaneous signals thus are obtained which then may be encoded according to National Television System Committee transmission specifications by using the necessary auxiliary equipment.

The slide changer section works in a manner somewhat similar to the cinecon section, except that no moving film or rotating prism is used. When the slide section is in use, the front-surface mirror is switched to a position where light from the cathode-ray tube is reflected to the slide changer section. Here it is focused through a lens system onto a 2- by 2-inch color transparency. This light, modulated by



Color Multi-Scanner produces color television pictures directly from 16-mm color films or color slides. A scanning light from a cathode-ray tube is focused by the lens through a multi-faced rotating prism onto a continuously moving film. The light, passing through the film, is picked up by a mirror system and split into its three basic colors which are filtered, picked up by three multiplier phototubes, amplified, and fed to additional equipment for transmission

passing through the transparency, is analyzed into its three component colors by dichroic mirrors, and is passed on to three phototubes, one for each color. The process for handling the three signals from this point on is the same as for movies.

In a color system, the most important factor is color quality. The importance of the Color Multi-Scanner lies in the fact that, in association with its auxiliary equipment, it can do more than merely reproduce faithfully the color of the film. In fact, it can improve on the original scene to produce the most pleasing effect for the viewer.

Du Mont engineers have accomplished this in a special unit known as an electronic color masker.

The masking facility allows a program director to control brightness and color saturation to obtain his desired results. In the case of commercial products advertised on television, the director can provide faithful color reproduction of the products. In programming, he may wish to change the picture to provide more pleasing results. A typical example of this is in the presentation of an outdoor scene, where grass and leaves tend to look better when colors are oversaturated, or in making a blue sky "bluer" while white clouds in the same scene remain unchanged.

Another advantage of the masking facility is the fact that it can make up for wide differences between two films—a duplicate Kodachrome, for example, requires more masking than an original Kodachrome. Operational control of the "electronic masker," incidentally, is relatively simple and is so set up to produce the desired picture on the control room monitor.

The Du Mont Chroma-Sync Teletron is a shadow-mask type of color picture tube using a 3-beam electron gun. In the Du Mont color teletron the color phosphors are applied directly to the curved face plate of the tube envelope by a photographic process, and the electron shadow mask has the similar curvature, and is positioned immediately behind the faceplate. The size of the color picture available on the Du Mont color teletron is $12^9/_{16}$ by $16^9/_{16}$ inches, which gives a useful picture of 185 square inches on a 19-inch round color envelope. Over 1,300-000 individual color dots of red, green, and blue phosphor have been deposited upon the screen and are arranged in triad form.

The shadow mask has the curvature similar to that of the faceplate itself. It is rigid and self-supporting. It does not require the use of tension for accuracy of alignment.

A new Mono-convergence 3-beam electron gun, developed by Du Mont, contributes considerably to the performance and design of the tube. A 60-degree deflection angle has been achieved which contributes to the short over-all length of the tube. The Du Mont 19-inch color teletron is 3/4 of an inch shorter than the 15-inch-type color tube familiar to the trade, nearly 2 inches shorter than a 19-inch tube of the planar-mask type. The Du Mont tri-beam electron gun has been so designed that there is simple common convergence of all three electron beams. This eliminates the need for individual dynamic beam convergence and associated circuitry in the receiver. As a result, the Du Mont 19-inch Chroma-Sync Teletron is essentially interchangeable in receiver circuits with the older 15-inch color-picture-tube types.

New Type Coaxial Cable System Can Triple Telephone Capacity

The Bell Telephone System has opened for service the major section of a new type of coaxial cable system capable of carrying more than 5,000 telephone conversations simultaneously.

The cable has triple the capacity of any voice transmission system now in use and a bandwidth double that of conventional video channels. Its components had been under development since near the end of World War II.

The new system was placed in service on a 916-mile New York–Chicago route, which passes through Newark, N. J., Philadelphia, Pa., and Cleveland, Ohio. This route bears the heaviest public and commercial communications traffic in the United States.

Ralph L. Helmreich, director of operations of the long lines department of American Telephone and Telegraph Company, said the number of circuits on the New York–Chicago route had jumped from 3,100 to 5,200 in the last 5 years, a growth of 70 per cent. He predicted the capacity requirements would continue to increase for several more years.

The carrier system presently used on most coaxial routes is known as the *L-1*. This system enables a pair of tubes to carry 600 telephone conversations simultaneously, or a single tube to carry one television program. The carrier system now being put in use on the New York–Chicago route is known as the *L-3*, and has even greater potential. This system makes it possible to transmit 1,800 conversations at the same time over the same pair of tubes without interference. It is also possible for two tubes—one in each direction—to carry two television programs and 600 telephone conversations simultaneously.

"The *L-3* carrier, which has been under development at the Bell Laboratories for several years, is a most important contribution to communications," Mr. Helmreich said. "It has a wider bandwidth than any coaxial system previously used and it is the first carrier system on which both television programs and telephone conversations can be sent together over a pair of coaxial pipes.

"The *L-3* will serve as an important adjunct to the automatic long-distance switching systems that are gradually being added to key cities in the Bell System network."

Mr. Helmreich said conversion of the route to *L-3* had taken more than a year and cost $10,000,000. He said 120 amplifying stations were already in existence along the route at about 8-mile intervals but that each station had to be re-equipped. The company also had to construct and equip 120 additional stations, placing each one halfway between the old stations. Thus, the route now has an amplifying station every 4 miles.

Four tubes in the New York–Chicago cable had now been converted to *L-3* between Chicago and Newark, N. J. Extensions to New York City and White Plains, N. Y., are due soon, in addition to the conversion of two more tubes along the entire route. The cable is to be used for telephone service initially. A second *L-3* project, now under construction between West Palm Beach and Miami, Fla., would be the first such system used for television.

Research and Training Reactors Available for Universities

The Atomic Energy Act of 1946 directs the Atomic Energy Commission (AEC) to distribute sufficient fissionable material to permit the conduct of widespread independent research and development activity to the maximum extent practicable subject to a number of conditions and limitations. In view of a rising tide of interest among the universities and other research institutions in acquiring reactors, the AEC has adopted a uniform policy for dealing with institutions requesting the loan of fissionable material for use in reactors for independent research and training.

Until recently it has not been feasible for universities and other research institutes to consider having reactors of their own, nor for the Commission to allocate the material for such purposes. Reactor designs were classified, fissionable material was in short supply, and the safety of reactors was unproved. Furthermore, facilities have not been available until recently to reprocess the material for return to the stockpile in case of emergent military need. During the first decade of the atomic energy project the only reactors available for research have been those in the National Laboratories. These have proved of great value for research in several fields of science and they have been used for basic investigations by visitors from independent laboratories as well as by the staff members of the National Laboratories themselves.

The steady advance of reactor technology has reached the point where it is believed to be both feasible and in the national interest to permit a few reactors to be built in the universities and research institutions. As a result of work sponsored by the Commission several reactor designs are available which provide simplicity, safety, and predictable operating characteristics at a cost level within reach of some universities. These designs are either wholly declassified or the classified features are so limited as not necessarily to prevent consideration by an independent institution. Furthermore, fissionable material is in sufficient supply to permit some allocation for research to institutions where there is evident technical competence and other assurances that the facility would be utilized efficiently and for purposes which are clearly in the public interest. Fissionable material is too costly and its supply is insufficient to allow the Commission, in the national interest, to make indiscriminate distribution; furthermore, loans of material cannot be made without some cost to the government. The burn-up of fissionable material in a low power reactor is small but not negligible, and extra costs are associated with the preparation of the material and with its reprocessing. These factors indicate that the Commission must make a careful appraisal of the purposes for which fissionable material is to be used, and of the competence of those to which its use is entrusted. It is of course not necessary that the use of material be restricted to those investigations which are intended to advance the immediate and limited objectives of the Commission. However, the Commission must be reasonably assured that the institution receiving fissionable material has the resources to make good use

of it for a reasonable period of time as represented in its application for the material. The AEC already has made a loan of 999 grams of U235 to North Carolina State College and Pennsylvania State University has been assured that fissionable material will be made available when its reactor is constructed.

The Commission will loan fissionable material for independent reactors, without charge for rental or processing, when this material is not in immediate demand for military or other use by the Commission, provided the Commission is assured by an examination of the evidence that:

1. The institution has a financial plan which adequately provides for the construction of the reactor and for its continued operation for a reasonable period of time.
2. The design and operation of the reactor will be in the hands of responsible and technically competent people.
3. The reactor will be used in a well-conceived research program which may be expected to contribute significantly to the training of students in nuclear research, engineering, or other fields of science.
4. The loan meets the requirements of the Atomic Energy Act and regulations of the Commission as regards the amount of material, security, classification, accountability, and health and safety.

The Commission will not commit itself to supporting the operation of such reactors nor to paying the costs of the buildings which house them. Subject to the availability of funds for the purpose, it will consider partial support of the construction of reactors at nonprofit institutions.

Miniature Tube Shield Reduces Tube Heat, Lengthens Life

A new type of heat-dissipating miniature tube shield developed by International Electronic Research Corporation (I.E.R.C.) is now in production and should prove of great benefit in reducing one of the major causes of tube failure, excessively high operating temperatures. The tube shield is designed to dissipate tube-generated heat by rapid conduction of the heat from the tube envelope to the chassis or heat sink.

Until recently, and especially in the general commercial field of household and industrial electronic equipment, the prime consideration in the use of tube shields was to provide electrostatic shielding and to prevent stray coupling between circuits. If the tube shield performed these electrical functions there was little concern over high operating temperatures, poor circulation of air, and heat trapping. Wherever noticeably excessive overheating troubles were encountered the equipment itself could be spread out. In the case of avionic equipment, which must be highly compact giving high power densities, the resulting operation in high ambient temperatures and at high altitudes has brought tube operating temperatures to the foreground as a problem that had to be overcome.

The tube shield is the result of much study and engineering research of these problems and is the best solution to date compared to results attained with other tube shields presently available to avionic equipment manufacturers. Extensive comparison tests have been made with other types of miniature tube shields using standard and modified Joint Army-Navy (JAN) shields. The tests were run as follows: a side-by-side arrangement of five *5763* beam power tubes on a chassis were set up and operated at rated filament voltage, 240 volts on the plate and drawing a plate current of 47.5 milliamperes. The glass envelope of each tube had three thermocouples attached, one at the top, middle, and bottom of the tube's plate. A series of JAN shields in bright and black finishes, with and without window cutouts, were attached. Three of the tubes were so JAN shielded, one tube had no shield, and one tube was outfitted with an I.E.R.C. tube shield. Tests were conducted with the test chassis so set up at normal room conditions (27.5 C) at standard sea level. The I.E.R.C. shielded tube operated at 78 C, 90 degrees lower than the highest recorded tube temperature in the group and 47 degrees lower than the bare tube.

The same tests repeated at 50,000 feet (simulated altitude) at 27.5 C room temperature proved the I.E.R.C. shield to operate 95 degrees C lower than the highest recorded tube temperature and 65 degrees lower than the bare tube. The manufacturer states that the improved cooling features offered by the I.E.R.C. tube shielding clamp are made possible by providing direct contact from the tube to the shield and then to the chassis to carry off generated heat. This direct contact is accomplished with metal spring fingers which rest on the tube providing support for the tube to minimize the effect of vibration and shock. Convection is aided through the use of windows and an open top in the shield for creating a chimney effect for heat escape. The improved mounting or base assists in transferring heat from the shield to the chassis or heat sink. Heat dissipation by radiation is assisted by a dull black finish on the shield. The I.E.R.C. shield occupies no more space than the conventional JAN-type shield, and is designed to restrict cantilever-type vibration of the tube to its socket, provides firm support for the tube by the spring fingers which prevent mechanical resonance of the tube under vibration conditions.

The new tube shield clamps are in production for all sizes of 7- and 9-pin miniature tubes. The new shields are designed to meet or exceed standards for present or future Air Force equipment and several companies are reported considering changing over existing equipment to the I.E.R.C. shield. They report this change is feasible because the I.E.R.C. shield base will fit chassis designed for JAN shields.

This type of vacuum-tube shield not only functions electrostatically but dissipates heat by conduction, convection, and radiation. The shield base, on the right, fits over the tube socket

AIChE Plans International Meeting on Nuclear Engineering

A week-long international meeting which will explore the chemical engineering aspects of nuclear processes is being planned by the American Institute of Chemical Engineers (AIChE). The meeting will be held June 20–25, 1954, at the University of Michigan, Ann Arbor, and experts from all over the world have been invited to participate.

The decision to issue invitations to foreign experts was made by the AIChE to afford both the American and foreign experts an opportunity to report the latest advances in their nuclear specialties at one meeting. It is believed that this is the first time that an attempt for such co-operation has been made outside of government auspices.

The program, which is expected to be the most comprehensive ever held on the subject, will begin with a day-long conference on the educational problems associated with training engineers in the nuclear field. A 2-day program is planned on the design of nuclear power reactors, and full technical discussion is scheduled in fuel resources, fuel preparation, chemical processing of spent fuel, disposal of radioactive products, use of isotopes, safety, instrumentation and control, and a conference on the social impact of the atomic age.

Proceedings Made Available for Manpower Utilization Conference

The "Proceedings of a Conference on the Utilization of Scientific and Professional Manpower" present the results of the Arden House conference sponsored by the National Manpower Council, October 11–17, 1953. The months that have passed have not lessened or altered the basic problems relative to the efficient use of our brainpower, nor are they any less urgent despite the Korean armistice and the current economic situation. For this reason, it is good that industry and the medical and teaching professions have access to the thinking that has been, until now, the property of the 66 conferees.

Major problems of utilization are introduced by J. D. Zellerbach, president of the Council, and are elaborated in papers by K. E. Boulding, professor of economics, University of Michigan; Frank Pace, Jr., executive vice-president, General Dynamics

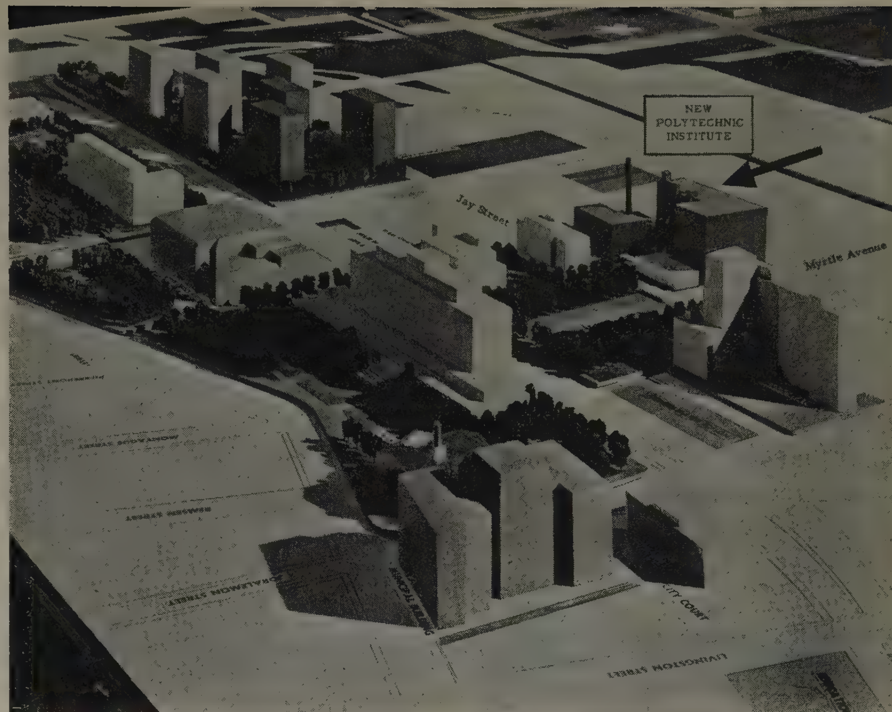
Corporation; and S. L. Wolfbein, chief, Division of Manpower and Employment, Bureau of Labor Statistics.

Effective utilization of engineering personnel was considered by a panel of 18 conference members. G. M. Maverick cautioned that the economic outlook indicates the wisdom of stressing quality and of deemphasizing quantity, while in the medical field M. D. Kogel threw the weight of the problem to the recruitment and training of supporting personnel.

Henry Chauncey pointed out that teaching seems to draw from the lower half of the college population as measured by intelligence tests, and is handicapped by low prestige, low salaries, poor working conditions, and limited promotion possibilities. Although supply was recognized as a crucial element in the present situation, the need to make the good teachers better by means of technological aids was a major topic of discussion.

Eli Ginzberg's summary of the six major approaches to better utilization of scientific and technological manpower gave point to Mr. Boulding's keynote talk stressing the need not for manpower but for men, whether to train, to plan, to lead, or to do. Technological or labor-saving aids are useful only in the hands of men competent to use them.

The "Proceedings" are available from Columbia University Press, New York, N. Y., at $3.50 per copy.



Arrow points to the gray models of existing structures of the American Safety Razor Corporation facing Jay Street which Polytechnic Institute of Brooklyn has contracted to purchase. Low white model in front of the two gray structures will be the new Polytechnic Library and Student Lounge

World Power Conference to Hold Sectional Meeting in Brazil

The sectional meeting of the World Power Conference will be held in Rio de Janeiro, Brazil, July 25 to August 10, 1954. The first week of the meeting is to be devoted to technical sessions, followed by a rather extensive study tour during the second week by bus and air lines.

The United States National Committee of the conference has been allocated 11 papers for the technical sessions. An extensive program of social activities also has been scheduled for the first week of the meeting.

For the second week, two separate parties have been scheduled for the inspection tour to make the journey in reverse directions with a common point of contact at Sao Paulo, Brazil. One of the schedules has been modified to permit attendance at the meeting of the Pan-American Federation of Engineering Associations (UPADI), which is holding its convention at Sao Paulo, August 2 to 12.

Both inspection tours will include visits to oil wells and refineries, hydroelectric and steam generating plants, and a steel plant.

Brooklyn Polytechnic Institute Buying New Site and Buildings

The Polytechnic Institute of Brooklyn has announced that it is acquiring a new site and buildings adjacent to the $80,000,000 Civic Center now under construction in downtown Brooklyn. It has contracted to purchase for $2,000,000 the site and 8-story block-long plant of the American Safety Razor Corporation.

Polytechnic Institute's physical capacity will be increased by 60 per cent, allowing it to centralize at one site facilities now scattered around downtown Brooklyn. At the same time it will preserve the central location near a variety of subways and other transportation lines that converge in that area.

Announcement that the contract to purchase the site has been signed with the title to pass to the institution in June, was made by Dr. Harry S. Rogers, president of the institute.

The American Safety Razor plant was deemed by architects and engineers to be ideally suited to the institute's purposes because of the structural specifications, including high ceilings, open areas, good lighting, and other features which lend themselves both to classroom use and experimental operations involving cumbersome machinery.

Actual possession of the properties will not be taken immediately, Dr. Rogers explained. He said that when title is acquired, the plant will be rented back to the manufacturing company for a period of 18 months or longer. He indicated that the institute will move to the new site as soon as the necessary funds are raised.

Third UPADI Convention Scheduled for August in Brazil

The third convention of the Pan-American Federation of Engineering Associations (UPADI) will be held in Sao Paulo, Brazil, August 2 to 12, 1954. Sao Paulo is celebrating the 400th anniversary of the founding of the city, and for that reason was chosen as the site of this meeting of Western Hemisphere engineers. The date of the meeting also was set so that engineers might attend both the UPADI convention and the sectional meeting of the World Power Conference.

At this meeting, the organization will continue its work on developing standards of practice and professional ethics. It will discuss methods of exchanging information on subjects of common interest. The most important objective of the convention, however, will be the establishment of good relations and understanding among engineers of the Americas.

Opportunities will be provided for tours to sites of interest near Sao Paulo and also for trips to Belo Horizonite and Rio de Janeiro.

Host for the convention will be the Brazilian Federation of Engineering Associations. A new slate of UPADI officers will be elected during the meeting.

Selective Service Tests Advisory Committee Program

A trial program for the purpose of testing the practical usefulness of an Advisory Committee on Scientific, Engineering, and Specialized Personnel is being put into operation in six states, Alabama, California, Michigan, New Jersey, New York, and Ohio.

For some time the Engineering Manpower Commission (EMC) and the Scientific Manpower Commission have felt that a principal reason for the continuing decline in the number of industrial deferments was the absence in the Selective Service System of provision for expert evaluation of industrial deferment requests to aid local boards in

reaching decisions. During 1953, EMC recommended to Selective Service and the Office of Defense Mobilization the formation in each state and territory of a committee to perform these functions within the Selective Service System.

The Selective Service System, feeling that the classification of certain scientific, engineering, and specialized personnel might present serious problems in a future mobilization, now has agreed to set up a trial program to test the usefulness of advisory committees for scientific personnel throughout the Selective Service System. This will be limited initially to six states in which it is believed the usefulness of the program can be tested easily.

Each State Director of Selective Service concerned has been issued instructions to establish a committee in his state. In establishing these committees, it must be thoroughly understood that the functions of the committees will be advisory only; that asking for or receiving advice or information from a committee will not be an abandonment of the responsibility of the local board to classify the registrant properly, nor will it be an abdication of any of the authority of the local board; that any advice or information emanating from a committee shall be made a part of the registrant's file only through his local board; and that the integrity of the local board will be preserved at all times. Within these limitations the test program will be organized and administered by each designated State Director in such manner as he believes best will test its value not only now, but also for a future operation.

The experience gained from this trial operation in the six selected states will serve as a guide in deciding whether to establish such committees throughout the Selective Service System.

Perfect Crystal of Pure Iron Opens New Metallurgical Field

The General Electric Company has disclosed the development of perfect crystals of pure iron, 100 times stronger than any known metallic crystal and inherently resistant to rust.

Explaining crystals as the building blocks that make up metals and alloys, Dr. C. G. Suits, vice-president and director of research, said the perfect crystals represent for the first time metals that are as strong as theory predicts they should be and, as such, "provide a new and exciting dimension in metallurgy."

He described the crystals as metallic whiskers about 0.001 inch thick and an inch or so in length.

He said they were produced in the company's Research Laboratory in Schenectady, N. Y., by Dr. Robert L. Fullman and Arno Gatti.

"No one knows today how to put these perfect crystals to practical use," he said. "We certainly cannot use them to support a suspension bridge. But their discovery is very recent. In time, applied science and technology will find a practical use for this form of metal."

According to Dr. Suits, the first observations of metallic whiskers were made at the Bell Telephone Laboratories. Telephone

A perfect crystal of pure iron, 100 times stronger than any previously known metallic crystal, is shown as viewed through a microscope. The crystal, a "whisker" 0.001 inch thick, is seen between an ordinary pinhead (left) and a tiny tool for manipulating

relays under test were found to fail in a mysterious manner, and research showed that whiskers of tin had grown and caused a short circuit.

Steel in machines and copper in electric motors, like all metals and alloys, are aggregates of crystals, so most problems of metals revert to problems of the component crystals, Dr. Suits pointed out.

One of the most important properties of metals and their alloys has to do with strength. He explained that metallurgists have calculated the theoretical strength of iron crystals to be such that one an inch square should support a million pounds or more. It has been a mystery why the strength of actual crystals is 100 times or so less than this. Metal parts used in machinery and other equipment similarly fall far short of the strength they might have theoretically.

Dr. Suits said that scientists recently have found that crystals previously made, thought to be nearly perfect, actually had atomic irregularities on an atomic scale. These defects caused the weakness.

"Now that we have learned to make some really perfect crystals for the first time, we find that they have astounding strength," he said. "They are stronger than any previously known metal or alloy, and actually attain a tensile strength of nearly a million pounds per square inch."

Moreover, he added, these tiny perfect crystal wires of pure iron do not appear to rust. Finely divided iron, or fine wires of ordinary iron, rusts almost immediately upon exposure to air.

"The same atomic perfection that gives them strength prevents oxidation," he explained.

In order to test the strength of these iron whiskers they are viewed under a microscope as they are bent by means of a micromanipulator. This is a device which makes possible small and accurately controlled movements.

Laboratory for Testing Gas Turbine Engines Completed

Completion of a gas turbine engine test laboratory at the Ford Research and Engineering Center in Dearborn, Mich., has been announced by Earle S. MacPherson, vice-president—engineering, Ford Motor Company.

Mr. MacPherson said the structure, to be known as the Pilot Gas Turbine Laboratory, is one of the most modern buildings of its type in the world.

The soundproof, fire-resistant facility will test gas turbine engines now being developed by Ford Engineering Staff's Scientific Laboratory as possible power units for future motor vehicles.

It is a one-story, windowless building made of brick, concrete, and aluminum. Shaped like a cross, it houses three test cells and a machinery room, all jutting from a central control room. It contains 4,104 square feet of floor space, plus underground fuel storage and fan rooms.

Gas turbine engine components can be operated separately, and as assembled units. To provide maximum safety, some test cell walls are 20 inches thick. Technicians will conduct test work by remote control from the central control room. They will look through wall ports made of thick layers of bullet-proof glass.

All air entering and leaving the laboratory will pass through labyrinth-type sound absorbing units. The test cell walls, roofs, and doors are soundproof.

A fume detector system protects against concentrations of combustible gases. In addition, the laboratory is equipped with water sprinkling and carbon dioxide system for fire protection.

Electron Picture Tube Stores Bright Halftone Pictures

An electron picture tube that can retain for several minutes a halftone picture so bright that it can be viewed even in brilliant sunlight was described recently by Dr. Max Knoll, H. O. Hook, and Dr. R. P. Stone, of the David Sarnoff Research Center of Radio Corporation of America (RCA), Princeton, N. J.

The new tube was developed as a simple electronic tool for direct daylight viewing of radar displays in an airplane cockpit or on the bridge of a ship. In such locations today, the relatively dim images on radar screens must be hooded to be observed. Even under a hood that cuts out all daylight, the viewer may have to wait for 2 or 3 minutes before his eyes become adapted to the low light level of the radar screen.

The RCA research men said they also envisaged use of such direct-view storage tubes in air-borne facsimile systems, oscilloscopes, and telemetry or wherever a bright electronic picture of brief or transient pictorial data needs to be held over extended periods for human viewing or photographic record-making. Similar tubes might be of value in television, they added.

The result of extensive study of storage tube problems and their solution, this new type of cathode-ray tube was developed by

RCA under a U. S. Army Signal Corps contract.

In appearance and in operation, the developmental tube is a distant cousin of the television kinescope. It uses controlled streams of electrons to paint a picture on a phosphor-coated screen on the face of the tube. But to obtain storage of and to present exceedingly bright pictures (five to ten times brighter than those on a standard kinescope), a number of different techniques are employed.

The new tube has three electron guns in its neck, each of which produces an independent stream of electrons. One of these, somewhat like the gun in a standard kinescope, "writes in" the picture signal. The second gun floods the viewing area with a continuous shower of electrons which produce the picture seen on the phosphor screen. The third is for "erasing" the stored picture when it has served the operator's purpose.

In a conventional kinescope, the writing beam directly scans the phosphors on the viewing screen making them glow and create a picture; in the developmental RCA storage tube the writing beam does not produce the picture directly. Instead, it scans a special storage grid mounted roughly 0.1 inch behind the phosphor screen. This grid is a fine-mesh screen with 160,000 openings per square inch supporting a thin insulating film. As the writing beam scans the insulating film on the grid, it builds up local electric charges of intensities that vary with the picture signal.

The flooding beam, which showers the grid continuously, will then pass through the charged openings on the grid in an amount proportional to the charges that have been built up by the writing beam. Thus the beam that actually creates the viewed picture is the flooding beam, not the writing beam.

The erasing beam, the operation of which can be controlled by the operator or automatically by associated circuits, alters the charges on the storage grid in such a way that the flooding beam is blocked at all points, causing the picture to disappear. The surface then is ready for new information to be written in.

The tube's operation might be compared to a window screen coated with heavy paint held above a table in the sunlight. If turpentine is traced on the screen, clearing paint from some of the holes, the sunlight can pass through and create an image of the window screen pattern on the table. Repainting the screen will cause the image to disappear.

In this analogy, the table represents the phosphor viewing screen in the tube and the window screen represents the storage grid. The action of the turpentine is comparable to the action of the writing beam; the sun to the flooding beam, and the repainting to the erasing beam.

The tube can retain high-resolution halftone pictures with no visible deterioration for some 30 seconds and usable pictures for several minutes. In radar scanning reproduction, the viewing duration need be only approximately 10 seconds before a new picture is to be displayed. In other applications where halftone reproductions are not required, such as receiving on an airplane's instrument panel continuous visual instructions (code digits and letters) transmitted from a ground station, the viewing duration of a single black-and-white image on the tube can be as much as an hour or longer.

In its present form for radar application, the tube has a 4-inch-diameter viewing screen which can present an image of hundreds of foot-lamberts in the highlights. To produce this high brightness the tube needs considerably less anode voltage than a kinescope, principally because of the tube's ability to light every spot on the viewing screen continuously instead of intermittently.

C. E. Kilgour Dies, Contributor to Proximity Fuze Development

Charles E. Kilgour, research engineer, Crosley Division, Avco Manufacturing Corporation, Cincinnati, Ohio, died suddenly on February 20, 1954.

Mr. Kilgour, born in Detroit, Mich., March 29, 1886, received the degree of civil engineer from the University of Cincinnati in 1910. He was one of the charter members of the Cincinnati Section, Institute of Radio Engineers (IRE), and served as chairman of that section during 1932–1933. He served on various national committees of the institute including Television and Facsimile in 1940 and Papers Procurement 1947–1948, 1949–1950.

At the end of World War II Mr. Kilgour received the Navy Ordnance Development Award for outstanding work on the Proximity Fuze Development Program. In 1951 he received the Fellowship Award by the IRE for his "contribution in the application of graphical methods to the analyses of detector and output tube performance."

He was associated with the Crosley Corporation activity and its successor, the Avco Manufacturing Corporation, for 34 years. He had served in the capacity of chief engineer, staff engineer, and research consultant.

New Type of Infrared Lamp Is Tubular and Made of Quartz

Development of a new type of infrared lamp, "of tremendous potential" for scores of heating, drying, baking, cooking, and other uses, has been announced by General Electric's Lamp Division.

It is a radical departure from any previous infrared lamp in two respects. It comes in a compact tubular shape, slightly larger in diameter than a cigarette, rather than in the shape of a conventional bulb. And rather than regular or heat-resistant glass, the tube is made of fused translucent quartz.

Producing more than four times the energy concentration delivered by the 250-watt infrared bulb, the slender quartz lamp has the ability to withstand high temperatures and the shock of violent temperature changes. Even when the tube is heated to a cherry red, it can be doused in water or, as a more severe test, may be touched by a piece of ice, without cracking.

Two sizes are being introduced, of 500 and 1,000 watts, for use on circuit voltages of 115–125 and 230–250, respectively. They have "lighted lengths" of 5 and 10 inches, metal clips on either end adding about $1^3/_4$ inches to the over-all lamp length. From each end extends a flexible 6-inch lead wire. As in all General Electric infrared lamps, the heating element is a coiled tungsten filament.

The many advantages of the new lamp include the following:

It produces higher energy concentrations in a small space—100 watts per lighted inch of tube length—than have been possible in the past.

It produces full radiation almost instantly, not requiring a warm-up period.

It produces visible light as well as infrared radiation, an advantage in some circumstances.

It is extremely light in weight. The 500-watt size weighs 3/4 ounce, and the 1,000-watt size 7/8 ounce, as compared with an ordinary teaspoon, which weighs 1 ounce.

It requires little maintenance, having a rated troublefree burning life of more than 5,000 hours.

The physical properties of fused quartz—its high mechanical strength, low coefficient of expansion, high melting point (about 3,200 F), superior insulating properties, and resistance to acids and thermal shock—are expected to contribute greatly to the new infrared lamp's versatility.

First application of the new lamp is expected to be in industrial radiant drying and baking ovens. Because of the higher energy concentration it makes possible, and because it provides energy over a considerable range of wavelengths, advantageous in many processes, the new lamp promises to open up new fields in industrial drying and baking.

Cooking—in ovens and surface burners of ranges, in home rotisseries, restaurant barbecue cookers, and food warmers—also offers an important early field of application for the quartz lamp. Its filament operates at about 4,000 F, and hence radiates more energy per watt than lower temperature sources.

House-heating equipment and space heat-

Despite the fact that it is heated to a cherry red, the new quartz infrared lamp is unaffected by the stream of water poured over it

ers are seen as important outlets for the quartz lamp. One type of unit employing the tubes is expected to be in the form of a ceiling heater which, by proper design, also provides some illumination. Other types include electric fireplaces, portable and wall-mounted heating devices. These may employ suitable red filters to reduce the light and create a desirable psychological effect.

A possibility for the lamps involves their installation at the marquees or entrances to department stores, office buildings, theaters, and other establishments, to keep window shoppers and others warm and comfortable in the wintertime. Similar installations are seen as desirable for bus and railroad waiting stations. Sufficient lamps in such locations would have the additional benefit of reducing the effect of snow and ice.

Many home appliances, in new designs, are seen as potential users of the new infrared lamps as their heating elements. These include clothes dryers, dish washers, water heaters, toasters, irons, coffee makers, deep-fat fryers, paint peelers, and hot plates.

Eventually the new infrared source is expected to be employed as therapeutic lamps for doctors' offices, homes, sterilizing equipments, and heat units for solaria.

On the farm infrared lamps are used for many purposes, and the new lamp is expected to be employed widely in brooders for chickens, pigs, and other animals because it offers the important advantage of compactness. Additional uses include the heat-processing of farm crops and seeds, thawing of frozen pumps, milk-house heating, and others.

Portable X-Ray Unit Has Potential Uses in Medicine

A small, inexpensive, and portable X-ray unit which has potential uses in medicine and industry has been developed by scientists at Argonne National Laboratory of the Atomic Energy Commission and is being tested as a diagnostic unit, the Laboratory has announced.

The active component of the instrument is a tiny particle of thulium which has been made radioactive in the heavy water nuclear reactor at Argonne. Thulium is an extremely rare material which heretofore has found little practical application. The thulium is mounted in a source holder and shield equipped with a shutter mechanism in order that X-ray photographs may be made. The shutter is operated by a standard photographic cable release.

The Argonne development which was directed by Samuel Untermyer, may meet the long-time need for simple, cheap, and portable equipment for making X-ray photographs. Although the entire unit weighs less than 10 pounds, the radioactive thulium provides rays which are comparable in energy to a 100,000-volt X-ray machine. The instrument does not require an electric power supply as does conventional X-ray equipment. In addition, it is quite inexpensive. Exclusive of irradiation charges, the total cost of the first model was $40.

The use of thulium as an X-ray source was first suggested by British scientists who have developed a similar but less powerful instrument. Excellent rare earth separation facilities and powerful reactors in the United States permitted development of the Argonne instrument which contains a thulium source several hundred times more powerful than the British units. This greater power makes the Argonne unit potentially useful for medical and industrial purposes.

For diagnostic purposes equipment of this type will be of greatest value in isolated locations such as army field hospitals, naval vessels, and isolated construction projects. Industrially, it has potential use as a density determination device. It may find considerable use in the determination of levels and densities of liquids in closed systems.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Engineering Institute of Canada

Editor's Note. The following letter was received by President Robertson from the Engineering Institute of Canada in reference to his "Message on Unity From the President" (*EE, Apr '54, pp 299–300*).

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Mr. Elgin B. Robertson, President
American Institute of Electrical Engineers
33 West 39th Street
New York 18, N. Y.

Dear Mr. Robertson:

The April issue of *Electrical Engineering* carries a "Message on Unity From the President." There are some references to the Engineering Institute of Canada (EIC) which are not in accordance with the facts, and which we believe are detrimental to the EIC. We are confident that you had no such intent in mind and therefore will welcome these observations.

We do not wish to take any part in a discussion of a problem which relates solely to U. S. societies, but as events in Canada have been mentioned as an argument for or against something, we feel an obligation to place before you the actual facts so that no one will be led to erroneous conclusions from erroneous premises.

In paragraph *c* you say, "The Engineering Institute of Canada was formed following World War I out of what was then the Canadian Society of Civil Engineers."

This statement is completely wrong and misleading. The EIC was formed in 1887 under a federal charter and has been active continuously since that time. It still operates under the original charter of 1887. In 1918 the name was changed, but there was no reincorporation and absolutely no change in the charter except for the name.

In the next sentence you say, "This institute proposed that it should be the National Engineering Institute to which all Canadian engineers of all branches should belong. This objective never has been reached."

The EIC never has made any such proposal at any time. One of its objectives was to establish *for* the profession, one institute to which all *might* belong regardless of their particular branch of engineering. There never has been any suggestion that all "should belong." Membership is voluntary and therefore no one can say that anyone or any group "should belong."

It is significant, however, that for over 67 years the EIC has been the leading engineering organization in this country and that today there are 16,000 members. On the basis of population this is a much higher membership than is enjoyed by any similar organization in North America. In fact it is almost the equal of the membership of all the leading purely engineering societies in the United States added together. It seems hardly fair to imply that the institute's "objective never has been reached."

In paragraph *d* you say, "The idea of a 'unity' organization in Canada was reborn during World War II largely to prevent engineers from being included within the scope of certain labor legislation." This is not so. The purpose of the organization was to provide some measure of unity, but without any specific reference to collective bargaining. Unfortunately it failed in its program, as was inevitable from the beginning because of its membership setup.

In paragraph *e* you refer to the Canadian Council of Professional Engineers and Scientists and say it "ran aground on the twin rocks of: (*a*) insufficient financial support, and (*b*) its impotence in that nothing could be done without reference back to its supporting societies." These conditions were indeed crippling but they were not the main reasons for it "running aground." It included in its membership architects, chemists, and dieticians as well as engineers. There was a lack of community interests among these groups. They had no common objectives, no common understanding on which to build and maintain a new society.

You say, "The Engineering Institute of Canada took exception to the organization, contending that it already existed in Engineering Institute of Canada." This too is not so. The EIC's unwillingness to support the proposed organization was based on the belief that no new organization was necessary in order to bring the engineers and scientists together to discuss and act on common interests wherever such matters arose. Already there were enough engineering organizations. The institute did not believe that a new organization could accomplish for the

engineers as much as could the senior officers of the existing societies if they would meet together from time to time as might be required.

Also, the EIC feared that such an organization with a heterogeneous membership, once it was organized would, like the famous horse, "gallop off in all directions," and get out of line with the thinking of the constituent members. That is precisely what happened. The institute's stand was justified thoroughly by subsequent events.

We feel it is unfortunate that the history of events in Canada should be misstated in your excellent publication and under your name. We realize of course that the fault is not yours. Probably the events have been reported to you by someone who was not thoroughly familiar with them or whose interests have given him, perhaps unwittingly, a prejudiced point of view.

As we read your report the EIC suffers unjustifiably. We hope the facts as outlined in this letter, all of which are well documented in the record, will be of value to you in dealing with the serious problem you have in mind. In view of the many readers your publication has in Canada, we would be grateful if you could see your way to having this letter published in *Electrical Engineering*.

Yours sincerely,

IRVING R. TAIT

(Vice-President, Engineering Institute of Canada, 2050 Mansfield Street, Montreal, Que., Canada)

Magnicon Generator

To the Editor:

My attention has been drawn to the very interesting article by Emanual Rosenberg, "The 50th Anniversary of the Cross-Field Dynamo" (*EE, Mar '54, pp 203–08*), and in particular to the author's reference on page 207 to my connection with the Magnicon armature-reaction-excited generator and its application to alternator voltage control. It should be made clear that the Magnicon generator was invented and developed entirely by J. C. Macfarlane and the holders (J. W. and W. I. Macfarlane) of the relevant British Patent 566,168, all of the Macfarlane Engineering Company, Glasgow, Scotland.

At the time that my article (reference 13 of Mr. Rosenberg's article) was written I was associated as an assistant designer with Crompton, Parkinson Ltd., who were (and still are) producing under license from the Macfarlane Engineering Company a range of alternators embodying the Magnicon principle. The object of the article was to provide a clear and concise account of the working principle of the Magnicon generator and its application to alternator voltage control and, although I hope that this object was in fact achieved, it should be made quite clear that I am due no part whatever of the credit for the development of this ingenious device.

If I may be permitted also a technical comment, I think it is a little inconsistent of Mr. Rosenberg to dismiss as "without importance" a development without which what he describes as the "very nice feature in its application as (an) exciter for small alternators" would be impossible; without the almost complete separation of main and control fluxes provided in the Magnicon the flux-balance error detector with a saturated pole insert as a reference quantity becomes virtually impracticable.

J. GRIFFIN

(20 Craigmont Crescent, Edinburgh, Scotland)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ASTM STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 888 pages, 9 by 6 inches, paper. $6. This latest annual compilation contains 156 specifications, test methods, and definitions relating to petroleum and petroleum products, covering crude petroleum, motor and aviation fuels, lubricating oils, turbine oils, bituminous materials, and other broad classifications. Much of the material in the previous edition has been revised and there are 11 new methods included. A new section gives a summary of changes made in ASTM standards in 1953.

DIRECT-CURRENT CIRCUITS. By Earle M. Morecock. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., second edition, 1953. 388 pages, 9¼ by 6¼ inches, bound. $5. Designed as a basic course for elementary study, this text provides theory, selected laboratory experiments, and a variety of problems for review purposes. A working knowledge of algebra and logarithms is required, but not calculus. In addition to the general aspects the book covers conductors and insulation, batteries, electromagnetic induction, capacitance, and electrostatics.

ELEMENTS OF ELECTRICAL ENGINEERING. By Arthur L. Cook and Clifford C. Carr. John Wiley and Sons, Inc., 330 West 42d Street, New York 36, N. Y., sixth edition, 1954. 682 pages, 9¼ by 6 inches, bound. $6.75. This standard textbook is intended as a short course for electrical students and for nonelectrical students in college. The extensive coverage, arranged to be used and combined as required, is divided as follows: fundamentals of electric and magnetic circuits; basic relations for electric machines; d-c machinery; a-c circuits; a-c machinery; instruments, electronics, special applications.

FORCED OSCILLATIONS IN NONLINEAR SYSTEMS. By Chihiro Hayashi. Nippon Printing and Publishing Company, Ltd., Osaka, Japan, first edition, 1953. 164 pages, 10¼ by 7½ inches, bound. $4.50. A detailed treatment for engineers and physicists, dealing only with systems having one degree of freedom. It applies a comprehensive method of analysis to a wide variety of periodic oscillations: Part I deals with steady-state conditions; Part II, with the transient state of oscillations leading to the steady state. Emphasis is on the comparison of conclusions derived from theory with experimental investigations carried out using electric oscillatory circuits with saturable iron cores as the nonlinear element.

HANDBOOK OF PROBABILITY AND STATISTICS WITH TABLES. By Richard Stevens Burington and Donald Curtis May. Handbook Publishers, Inc., Sandusky, Ohio, 1953. 332 pages, 8 by 5½ inches, bound. $4.50. This summary of theory, working rules, and tabular material provides a compilation of selected data for all engineers and research workers who have use for statistical procedures. Particularly useful for operations research and analysis, the book provides basic data for evaluation of performance and worth, quality control, and other management problems.

MAGNETIC FIELDS OF CYLINDRICAL COILS AND ANNULAR COILS. (Applied Mathematics Series, No. 38.) National Bureau of Standards. Distributed by Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1953. 29 pages, 10¼ by 8 inches, paper. 25¢. Mathematical formulas are developed for the axial and radial components of the magnetic field produced by cylindrical coils carrying an electric current. Cases treated include cylindrical current sheet, circular current sheet (with circumferential flow of current), and multilayer solenoid

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

THE RADIO AMATEUR'S HANDBOOK, 1954. American Radio Relay League, West Hartford, Conn., 31st edition, 1954. Various paging, 9½ by 6½ inches, paper. $3. This standard manual of amateur radio-communications covers the entire field from the fundamentals to the latest techniques in equipment, design, and construction. The considerable amount of technical data provided includes a comprehensive, up-to-date section of vacuum-tube data tables. The advertising section contains condensed manufacturers' catalogues. As usual, the new edition has been revised to conform to current practice, notably the chapter on very-high-frequency receivers.

STATIC ELECTRIFICATION. (British Journal of Applied Physics, supplement no. 2.) Institute of Physics, London, England, 1953. 104 pages, 10¾ by 8 inches, stiff covers. 25s. The first paper in the report of this symposium is on the theory of contact electrification. Then follows a series of papers on general principles of static electricity generation and dissipation; four papers on useful applications, including coating processes and the measurement of the oxidation of coal; and three papers on electrostatic machines. The last group of papers covers harmful static electrification—its elimination in the textile industry, its effects on rubber tires of vehicles, and other aspects of the subject.

STAUANLAGEN UND WASSERKRAFTWERKE. Part 1: Talsperren. By Heinrich Press. Wilhelm Ernst and Sohn, Berlin, Germany, 1953. 212 pages, 9½ by 6¾ inches, paper. DM 26. Part I of a series on dams and hydroelectric generating stations, this volume gives a concise but comprehensive description and analysis of the various types of modern gravity, buttress, and earth dams for both the student and the practicing engineer. The text is supplemented and illustrated by a wide range of examples of existing dams.

TABLES OF CIRCULAR AND HYPERBOLIC SINES AND COSINES. (Applied Mathematics Series, No. 36.) National Bureau of Standards. Distributed by Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1953. 407 pages, 10½ by 8 inches, bound. $3. Values of circular and hyperbolic sines and cosines are given to nine decimal places for a range of x from 0 to 1.9999 at intervals of 0.0001. A few errors in the first two editions have been corrected, and Supplementary Table III has been extended, now expressing degrees, minutes, and seconds in terms of radians to ten decimal places and the reverse conversion to an accuracy of 0.000005 second.

TELEVISION BROADCASTING. By Howard A. Chinn. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1953. 700 pages, 9¼ by 6¼ inches, bound. $10. Most of the technical aspects of the operations of television broadcasting stations are covered in this text which will be of particular interest to engineers engaged in the design of television equipment and systems. There are chapters on fundamentals, cameras, field equipment, projectors, film, recording, transmission, and other subjects. The concluding chapter reviews characteristics of Federal Communications Commission standard color television signals and the conversion of monochrome pickup equipment for color operation.

LE CONTROLE STATISTIQUE DES FABRICATIONS. By R. Cavé. Éditions Eyrolles, Paris, France, 1953. 430 pages, $9^3/_4$ by $6^1/_2$ inches, bound. Ffrs. 3,950. This practical treatise begins with a section on statistical theory, including the fundamental laws of probability and distribution. Production and quality control then are analyzed in detail, covering sampling, acceptance lots, and other major aspects. The application of statistical methods to research also is dealt with at considerable length. Tables, graphs, and a section of useful monograms supplement the text.

THE CYCLOTRON. By W. B. Mann. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., fourth edition, 1953. 118 pages, $6^3/_4$ by $4^1/_4$ inches, bound. $2. An account of the development of the 37-inch cyclotron at Berkeley, Calif., first published in 1940. In this new edition, minor textual alterations have been made, a chapter has been added covering some of the developments of the last 15 years, and the bibliography has been brought up to date.

FRESH WATER FROM THE OCEAN. For Cities, Industry, and Irrigation. By Cecil B. Ellis and members of the staff, Nuclear Development Associates, Inc. Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1954. 217 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $5. In its investigation of the possibilities of drawing fresh water from the ocean on the grand scale of a billion gallons per day, this book analyzes the basic matter and energy relationships with which any sea-water conversion method must deal. To determine their economic feasibility the various methods are assessed in terms of the major cost elements such as plant construction and power requirements. By-products are considered briefly.

GUIDANCE PROCEDURE FOR THE NEW YORK PROFESSIONAL ENGINEERS LICENSE. By John D. Constance, 625 Hudson Terrace, Cliffside Park, N. J., first edition, 1954. 24 pages, 11 by $8^1/_2$ inches, paper. $1. This manual, written to aid the engineer seeking a professional license in New York State, can be used also by applicants in other states, since New York procedure and requirements are based on the model law adopted to some extent by other states. Information is included on general procedures, the meaning of qualifying experience, application forms, methods of recording experience, the philosophy and purpose of the written examination, experience requirements for licensure without written examination, etc. Some of the material appeared previously in the journal *Power Engineering*.

DIE LAPLACE-TRANSFORMATION UND IHRE ANWENDUNG. By Paul Funk, Hans Sagan, and Franz Selig. Franz Deuticke, Vienna, Austria, 1953. 106 pages, $8^1/_4$ by $5^3/_4$ inches, paper. $2.40. A brief textbook for engineers and physicists on the application of the Laplace Transform. It is intended to fill the gap between the mathematical treatise and the strictly engineering treatment. A supplement gives a brief history of the development of the subject.

MAGNETIC-AMPLIFIER CIRCUIT. By William A. Geyger. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1954. 277 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $6. By the use of descriptive and graphical methods rather than mathematical treatment, the author of this book gives a relatively simple and practical exposition of the fundamentals and applications of magnetic amplifiers, with special reference to magnetic servoamplifiers. Opening chapters cover the classification of saturable-core devices, the history of magnetic amplifiers, and the materials, construction, and winding of cores. The greater part of the book is devoted to circuits—nonfeedback, single-stage, and multistage with external or internal feedback, and others. References are listed after each chapter.

MAGNETIC COOLING. (Harvard Monographs in Applied Science, number 4.) By C. G. B. Garrett. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 110 pages, $8^1/_2$ by $5^3/_4$ inches, bound. $4.50. A monograph concerned with methods of attaining temperatures below 1° absolute and experiments on materials at such temperatures. Technical aspects of magnetic cooling, including the problem of determining absolute temperature, are treated first. Thermodynamic properties of the paramagnetic salts used in the process are surveyed next and consideration given to the quantum theory of paramagnetism and theories of low-temperature magnetic co-operative effects. Finally, there is a review of experiments at low temperatures on helium, on the superconductivity and resistance minimum of certain metals, and on nuclear alinement.

LOW-FREQUENCY AMPLIFICATION. By N. A. J. Voorhoeve. Philips' Technical Library, Eindhoven, Netherlands (available in U. S. from Elsevier Press Inc., 402 Lovett Boulevard, Houston 6, Tex.), 1953. 495 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $9. A comprehensive handbook on low-frequency amplifiers, which deals with the design and use of component parts and their assembling into sets and installations. Particular importance is paid to the theory of sound, to the principles guiding the assembling of large installations incorporating long low-frequency conduits, to amplifier current supply, and to the major electrical components. Theoretical detail in general has been kept to a minimum.

LA MACHINE-OUTIL. Edited by A. R. Métral-Dunod, Paris, France, 1953. Volume I: Généralitiés-Machines-Outils Et Usinage. 336 pages, 11 by $7^1/_2$ inches, bound. Ffrs. 4,400. Volume IV: Usinage Par Outils En Translation. 351 pages, 11 by $7^1/_2$ inches, bound. Ffrs. 4,600. Volume I of this set begins with an introductory discussion of machine tools and the machine-tool industry in the principal countries of the world. It then deals with the following topics: metallurgy in relation to metal cutting; design of castings for machine elements; theoretical and practical aspects of metal cutting with tools of various types; cutting fluids; maintenance. Volume IV provides detailed coverage of planing, shaping, mortising, slotting, and broaching machines including operation analysis.

MAGNETIC AMPLIFIERS. By George M. Ettinger. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 88 pages, $6^3/_4$ by $4^1/_4$ inches, bound. $1.50. This small book is entitled "Magnetic Amplifiers" as these are the subject of the more important chapters. The scope, however, extends from the simplest forms of saturable reactors to high-sensitivity magnetic modulators. The object is to assist the practicing engineer in selecting the most suitable device for a measuring or control function and to serve as a starting point for research.

MODULATORS AND FREQUENCY-CHANGERS. By D. G. Tucker. Macdonald and Company, Ltd., London, England, 1953. 232 pages, $8^3/_4$ by $5^3/_4$ inches, bound. 28s. A book for engineers concerned with the design and use of amplitude modulators and amplitude-modulation systems, and also of interest to advanced students of communications. Modulation is treated as a deliberate process taking place in circuits designed specifically for it, and practical modulators are dealt with after a consideration of ideal ones. A bibliography is included which is referred to throughout the text.

PRINCIPLES OF NUMERICAL ANALYSIS. By Alston S. Householder. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 374 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $6. A unified presentation that develops the mathematical principles upon which many computing methods are based. Directed primarily toward high-speed digital computation, the book also contains much useful material for "hand" computation. It covers specifically matrices and linear equations, nonlinear equations, interpolation and other approximations, and the Monte Carlo method.

PROCEEDINGS OF 1953 CONFERENCE ON NUCLEAR ENGINEERING. University of California, Berkeley, September 9–11, 1953. California Book Company, Ltd., 2310 Telegraph Avenue, Berkeley 4, Calif., 1953. Various paging, $10^3/_4$ by $8^1/_4$ inches, paper. $7.50. Thirty-three contributed papers on nuclear power are reprinted under the following subject groups: reactors—power and research; equipment for neutron research; nuclear power-plant economics; nuclear kinetics, instrumentation, and control; materials for reactor components; accelerator engineering; uses of isotopes and nuclear radiations. Two special papers deal with a nuclear-power program and metals for reactor-core construction.

RADIO ENGINEERING, VOLUME I. By E. K. Sandeman. Chapman and Hall Ltd., London, England, second edition, 1953. 779 pages, 9 by 6 inches, bound. 60s. As in the first edition (1947), the object of this comprehensive work is to present the principles of radio techniques in a form easily understandable to the novice, while at the same time providing a useful reference book for experienced engineers. This edition has been thoroughly revised and a large number of minor additions have been made. Major additions are a new section on transmission-line filters and a statement of the method of calculating the noise factor of a receiver. Volume I covers from the fundamental electric units and circuits through the characteristics of aerials.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

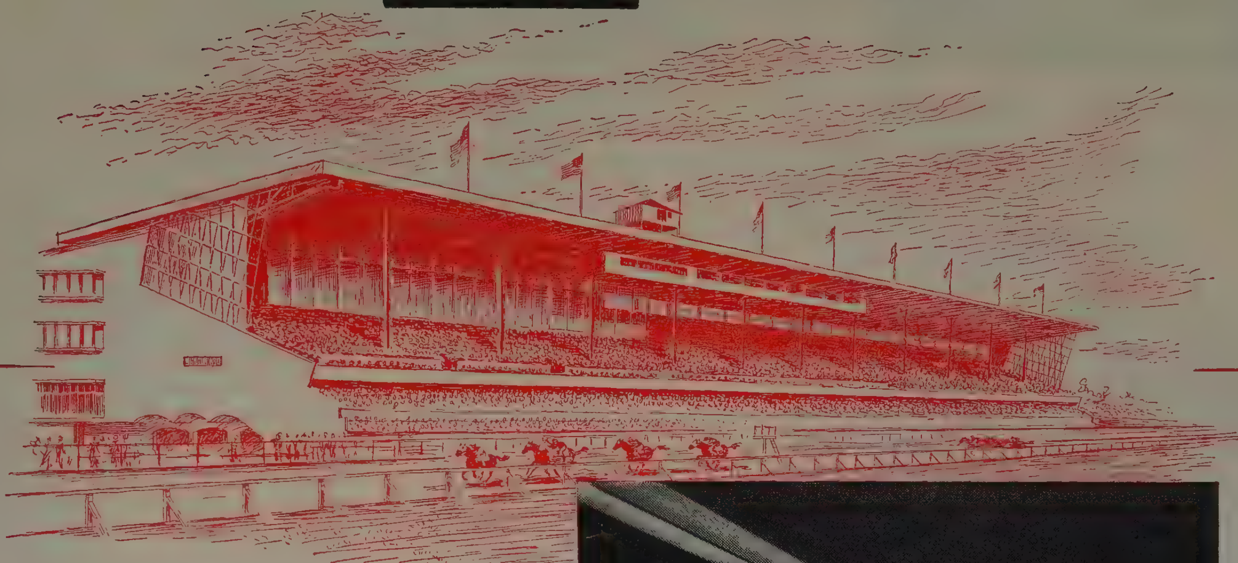
Copper-Manganese-Tin Alloys. "The Structure and Mechanical Properties of Copper-Manganese-Tin Alloys" has been issued by the Tin Research Institute. It describes a range of new alloys which may be useful in the fields hitherto served by nickel silver. The alloys meet the demand for a white metal with good mechanical properties at a competitive cost. It can be cast, forged, rolled, stamped, etc., readily and has an adequate resistance to corrosion. The publication gives detailed information on the properties of a wide range of compositions and indicates how compositions and methods of treatment may be varied to give strength, color, or deformability, etc., as may be required. Copies of this paper, originally published in the *Journal* of the Institute of Metals, may be obtained free from the Tin Research Institute, Inc., 492 West Sixth Avenue, Columbus 1, Ohio.

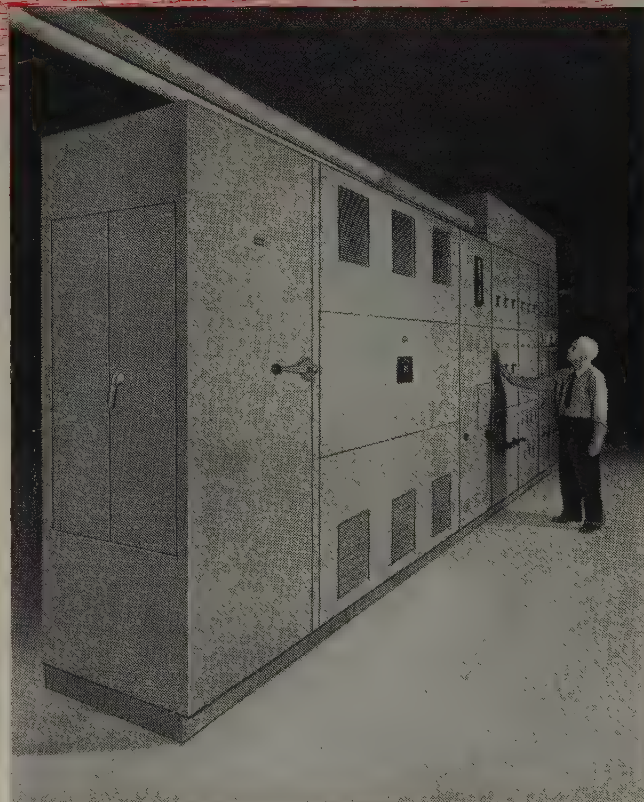
Automation and Other Technological Advances. Papers on automation, use of radioactive isotopes in industry, and materials substitution. These papers were presented at the Manufacturing Conference of the American Management Association held in December 1952. 55 pages. $1.00 (to American Management Association members), $1.25 (to nonmembers). Order from the American Management Association, 330 West 42d Street, New York 36, N. Y.

Magnetic Fields of Cylindrical and Annular Coils. This publication gives the axial and radial components of the magnetic field at any point in space of a cylindrical or an annular coil carrying an electric current. The results are expressed in terms of complete elliptic integrals or of Legendre functions which involve ratios of the significant dimensions of the coils. Formulas are given for computing in full detail the magnetic field itself, point by point. 29 pages. 25¢. Order from Government Printing Office, Washington 25, D. C.

Electron Tube Reliability. A report entitled "Investigation of Electron Tube Reliability in Military Applications" has been published by Aeronautical Radio, Inc., an organization currently conducting an extensive study of military electronic tube reliability for the U. S. Army, Navy, and Air Force under a Bureau of Ships contract. The report covers the period from April 4, 1951, through March 31, 1953, and describes the scope of the surveillance program, the methods of tube collection and of engineering and statistical analysis, and the result of the program to date. Incorporated in the report are 65 tables, 24 charts and photographs, and a statistical appendix. 97 pages. 50¢. Available from L. E. Davis, Aeronautical Radio, Inc., 1523 L Street N. W., Washington 5, D. C.

FEDERAL NOARK® POWER CENTER... THE WINNER AT LAUREL!





IT TAKES ELECTRICITY to operate a race track. Without electricity you'd have trouble buying an admission ticket or placing a bet . . . and how could the horses get through the gates or give you a photofinish? Well, Laurel, in Maryland, is today's most modern track, and its electrical system is controlled by Federal Noark main service equipment, lighting and power panels, motor controls, control centers and a unit substation.

Federal Noark equipment is today's best answer in buildings of every type and wherever else there's an electric light and power control problem. Most of this equipment is factory-assembled from standard units to meet individual specifications. All of it brings minimum installation costs . . . and is designed for maximum efficiency, easiest maintenance and remarkable flexibility for later changes or expansion.

Next time you have an electrical distribution problem, pass it on to Federal Noark for the most practical and economical solution.

Federal Noark Power Center at Laurel Race Course. Factory-assembled and tested. Circuit breakers completely interlocked in all positions . . . high voltage switches coordinated with power fuses. Complete sectionalizing between high and low voltage and individual breakers makes maintenance safe and easy. On the complete Laurel electrical system, Architect was Arthur Froehlich, Beverly Hills, California; Contractor, Harry S. Mickey, Baltimore, Maryland.

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Federal Noark products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct — **Pacific Electric Manufacturing Corporation products:** High voltage circuit breakers and power switches ★ Sales offices in principal cities.

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INDUSTRIAL NOTES ....

Electrical Engineering Cited. J. S. Lopes, advertising director of *Electrical Engineering*, has been honored by the board of directors of The Advertising Council for the magazine's "most generous advertising support" of council campaigns from 1949 to the present.

General Electric News. Ground was broken recently at Waynesboro, Va., for a new General Electric company plant which will manufacture electronic controls for industrial and aviation use. The new factory is being built in anticipation of projected heavy demands for such equipment as electronic drives, adjustable speed drives, speed regulators, aircraft and regulating equipment, and similar devices.

Four new appointments to marketing positions in the company's light military electronic equipment department follow the integration of government marketing activities with other operations of the military department. They are William F. Hafstrom, manager of sales; Charles W. Nelson, manager of product service; Benjamin Parran, manager of marketing research and product planning; and Robert T. Pennington, manager of marketing administration.

The establishment of a new advance and development unit within the engineering section of the company's silicone products department was announced. Dr. Robert O. Sauer was named manager of this unit, with the title of manager, advance and development engineering.

Establishment of a camera tube project, as the first step toward production of image orthicons and vidicons for television cameras, is in the production planning stage in the industrial and transmitting tube plant, with commercial production of the tubes scheduled for 1955. Named as manager of the camera tube project was Harry L. Thorson, who has been with General Electric since 1933.

S & C Appointments. The S & C Electric Company recently created four vice-presidencies, and the following men have been appointed to fill these positions: S. I. Lindell was appointed vice-president, engineering; C. C. Martin, vice-president, manufacturing; A. B. Chilcoat was appointed vice-president, material; and L. M. Thompson, vice-president, controller.

Bennett Named Chairman. Election of Irving T. Bennett as chairman of the board of General Cable Corporation was announced. He will continue also as the company's chief executive officer, a position he has held since August 1953. As chairman, he succeeds D. R. G. Palmer who is retiring after 35 years with General Cable Corporation and its predecessor companies.

Regional Manager Named. Don L. Orton has been appointed North Central regional manager for the Federal Electric Products Company and the Pacific Electric Manufacturing Corporation, a wholly owned subsidiary of Federal Electric. He will be responsible for sales of the combined Federal-Pacific line of high- and low-voltage switchgear, control, and distribution equipment in Indiana, northern Illinois, North and South Dakota, eastern Iowa, Wisconsin, and Minnesota.

Raytheon News. Sidney A. Standing of Short Hills, N. J., has been appointed manager of Raytheon Manufacturing Company's Cathode Ray Tube Division. He will make his headquarters in the electronic firm's new cathode-ray-tube plant in Quincy, Mass.

Thomas J. Kelly, of Weston, Mass., has been appointed director of licensing for the company's international operations. Mr. Kelly was formerly manager of the Waltham electronics firm's commercial service division.

A new, ultramodern, $2,000,000 electronics laboratory was opened officially at the entrance of the new structure overlooking Hanscom Air Force Base, Bedford, Mass. The U. S. Navy began construction of the building late in 1952, when it was planned that Raytheon would use the structure as a Navy research and development center.

Maurice S. Hartley, of Wellesley, Mass., has been promoted to the position of product manager of the company's industrial electronics equipment. He will direct the marketing activities for the Waltham firm's industrial product lines.

Du Mont Appointment. Leonard A. Bayer has been appointed to the position of manager of the product engineering department of the Communication Products Division. The appointment will co-ordinate the translation of product designs into equipment ready for mass production.

RCA Vice-President. Election of Frank Sleeter as vice-president, facilities administration, of the Radio Corporation of America (RCA) has been announced. Mr. Sleeter, who joined RCA in February 1946, was director of plant engineering from June 1946 until last January, when he was named director of plant facilities administration.

Westinghouse Promotions. Franklin P. Hinman has been named acting manager of manufacturing, and Harry F. Pully has been appointed to the newly created position of acting manager of the Electronic Tube Division's Elmira, N. Y., plant.

McMullen Named to New Post. J. W. McMullen, general manager of the Pittsburgh (Pa.) Works of Allis-Chalmers' Manufacturing Company, has been named vice-president in charge of transformer and switchgear equipment. Mr. McMullen will be responsible for operations at the

(*Continued on page 28A*)

(*Continued from page 26A*)

Pittsburgh Works and the Boston (Mass.) Works and for all transformer and switchgear operations at Hawley, West Allis, and Terre Haute plants. He will be located at the West Allis (Wis.) Works.

New General Manager. E. W. Glasenapp has been appointed general manager of the resistor department of Victoreen Instrument Company. The company is the oldest American manufacturer of medical X-ray and radiation measuring instruments. Executive offices are located at 3800 Perkins Avenue, Cleveland, Ohio.

SRI's New Division. Stanford Research Institute (SRI), major public service applied research organization of the West, has started operation of its new Pacific Northwest Division with the establishment of an office in Portland, Oreg. Located in the Equitable Building in the central business district of Portland, the office has been set up at the request of Oregon business and civic leaders. Through its Portland office, the institute expects to launch a research program on problems of long-range development of power and water resources of the Pacific Northwest, working closely with other groups and interests in the area. Named as manager of the Portland office is Patrick M. Dowling, a specialist in area development research and formerly assistant to the director of international research at SRI.

New Research Laboratory. The National Vulcanized Fibre Company of Wilmington, Del., has announced plans for a modern research laboratory to enlarge the facilities of the company's research and development section. The laboratory will be housed in what is currently a large stone warehouse at Yorklyn, Del., near Wilmington. The building will be completely renovated and covers 20,000 square feet.

NEW PRODUCTS • •

New Type of Fluorescent Lamp. General Electric Company recently unveiled a new type of fluorescent lamp which produces 35 per cent more light than any previous fluorescent light source. First of the new line is a standard cool white lamp, 8 feet long, and with a diameter of 1 1/2 inches. Rated at 110 watts, it has a total light output of 6,800 lumens, or almost three times that produced by the popular 4-watt size. Its rated life is 7,500 burning hours. Although of the same wattage, the new lamp emits more than 44 times as much light as Edison's first practical incandescent lamp. An important feature of the lamp is a base of entirely new design. It incorporates two contacts recessed in a single element, and allows the lamp to be inserted easily and safely in push-pull type of lamp holders.

(*Continued on page 32A*)

ASA, AIEE and NEMA STANDARD

PORTALS OF POWER

PACIFIC ELECTRIC CIRCUIT BREAKERS

STANDING GUARD over an apparatus and line investment of millions are these two (of five) 230-kv, 1200-amp, Type RHE Pacific Electric Oil Circuit Breakers . . . in the switchyard of a 625,000 kw steam plant nearing completion in the Far West.

Each circuit breaker has a 3-cycle interrupting rating of 10,000,000 kva.

All 230-kv and 115-kv air switches for disconnecting, by-pass, bus transfer, and sectionalizing in the switchyards of this plant are also Pacific Electrics.

Pacific Electric High Voltage Outdoor Switchgear . . .

Oil circuit breakers and air switches, 7.5 to 287.5 kv.

Distribution service restorers.

Power-fuse and distribution switches, cutouts, and supports.

THE SELECTION of Pacific Electric circuit breakers for key-point duty on many leading power systems is recognition of their proved protective performance, reliability, and low cost of maintenance.

FEATURES

- Simple self-pressurizing interrupters; their exceptional performance is due to improved utilization of directed oil flow and to high speed of developing open-gap distance.
- Only one moving structure within each tank.
- Oil-hydraulic restoration of closing energy.
- Opening accelerating springs and shock absorbers are outside of the tanks.
- Electrically and mechanically trip free in any position, even during high-speed reclosing.

Since 1906

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PACIFIC ELECTRIC MFG. CORPORATION

SUBSIDIARY OF FEDERAL ELECTRIC PRODUCTS COMPANY

5815 THIRD STREET, SAN FRANCISCO 24, CALIFORNIA
OTHER FACTORIES: SANTA CLARA, CALIF.; SCRANTON, PENNA.

(*Continued from page 28A*)

Resins. Isocyanate Products, Inc., a newly formed corporation of Delaware, is producing foamed-in-place resins based on reaction products of polyisocyanates. Licensed under the Du Pont patents, this company is marketing 2-part liquid formulations under the trade name of IPI-ISOFOAM. It is a new foamed-in-place, polyisocyanate expansible resin, which is self-cured to produce a low-density product with a multiplicity of applications. A number of two component formulations are available, which upon mixing just before use, will expand to resilient foams of 2 pounds per cubic foot density, ranging to rigid foams of 20 pounds per cubic density.

Servo Motor With Tachometer Generator. Small, lightweight motor generators for use in servo controls have been announced by G-M Laboratories, Inc. The generator is housed in the same case with the servo motor. Weighing approximately 4 ounces, the dual unit measures 63/64th inch in diameter by $2^5/_{32}$ inches long. The maximum moment of inertia is 2.9 gm-cm^2. The motor is a 2-phase unit with an input of 26 volts per phase at 400 cycles, power input is 3.75 watts per phase, stall torque is 0.35 ounce-inch and has a no-load speed of 6,500 rpm. The generator provides an output of 0.32 volt per 1,000 rpm. Maximum null voltage at 0.023 volt. Units for other frequencies and voltages are available. Direct inquiries to G-M Laboratories Inc., 4300 North Knox Avenue, Chicago 41, Ill.

Compact Pulse Generator. Continuously adjustable pulse durations from 0.2 microsecond to 60,000 microseconds are available from the new Type *1217-A* unit pulser. A small, economical instrument, the pulser is powered by the Type *1203-A* unit power supply to which it is easily attached. A self-contained oscillator drives the output at 12 fixed frequencies from 30 cycles to 100 kc, and provision is made for external triggering at any frequency below 100 kc. The pulse rise time is less than 0.15 microsecond. The open-circuit output voltage is 20 volts for pulses of either polarity. The internal output impedance is about 200 ohms for positive pulses, and 1,500 ohms for negative pulses. For further information write to General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass.

Junction Box Assemblies. Line Material Company has announced the availability of factory-wired junction box assemblies for use with *NR* oil switches on capacitor banks. These assemblies provide a convenient means of interconnecting switch circuits with other control circuits, and they afford a savings through reduced labor charges for field installation and maintenance. Each assembly consists of a cast aluminum box with a gasketed aluminum cover, a terminal block, three multiconductor cables, and a hanger for cross-arm mounting. For further informa-

(*Continued on page 36A*)

(*Continued from page 32A*)

tion, write Line Materials Company, Milwaukee 1, Wis.

Colortone Frequency Meter. A new precision frequency-measuring instrument has been announced by Colortone Electronics, Inc., 238 William Street, New York 38, N. Y. Designated as *TS-175 A/U*, the frequency meter has a frequency range of 85–1,000 megacycles; calibration accuracy: ± 0.005 per cent; stability: ± 0.0025 per cent. The manufacturer will be glad to furnish further information on applications.

Cotton Card Gearmotor. A new gearmotor drive for cotton card machines is available from the Westinghouse Electric Corporation. The new unit mounts directly on the card shaft, and eliminates the need for line shafts and belting. A torque arm anchors the unit to the card frame, and prevents the gearmotor from turning. The whole assembly requires approximately the same aisle space normally required for a belt pulley. A double-reduction set of helical gears reduces motor speed to proper card-operating speed. For further information, write Westinghouse Electric Corporation, Gearing Division, Department T-081, 200 McCandless Avenue, Pittsburgh 1, Pa.

Three New Test Instruments. Development of three types of electronic test equipment essential to installation and maintenance of home color television receivers has been announced by the Tube Division, Radio Corporation of America (RCA). The equipment, which is scheduled to be commercially available in the near future, includes: the industry's first service-type color-bar generator (RCA *WR-61A*), which produces, on a receiver screen, a multiple-color test pattern of 10 color bars for adjusting color phasing and matrixing circuits; the first portable dot-bar generator (RCA *WR-36A*); and a 5-inch dual-bandwidth oscilloscope (RCA *WO-78A*), for observing the color-burst signal, and for checking the operation of the color-burst circuit.

I-T-E Circuit Breaker. The new 2-pole *EQ* molded-case I-T-E Circuit Breaker Company's circuit breaker is designed for use in panelboards, load centers, or individual enclosures. The circuit breaker has a common tripper bar arrangement as an integral part of the trip mechanism which eliminates the handle tiebar previously used to join two single-pole circuit breakers together. It is available in ratings from 10–50 amperes; 120/240 volts alternating current; 5,000 amperes interrupting. For further details write to the Small Air Circuit Breaker Division, I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

GE Announces New Motor. A new sump-pump motor, 25 per cent lighter than previous models, has been announced by the General Electric Company's general

(*Continued on page 48A*)

gain from the coast to coast acceptance of

Rome power and control cables

Are there any doubts in your mind concerning the power and control cable you should specify for your requirements? Then consider this—

From Pacific Gas & Electric's new 600,000 KW plant at Pittsburg, California, to Niagara Mohawk's new 400,000 KW station near Albany, New York, there are hundreds of utilities whose experience with Rome cable can guide YOU in saving time, work and risk of costly failure.

These two facts show you how:

First, in relation to over-all expense of plant and equipment, cable is your smallest item of expense. But it can be the most costly, if it fails! Therefore, it pays to buy the best.

Second, many products—and cable is one of them—look alike. They must meet Underwriters Laboratory requirements. But it's the people behind the product—the precautions they take in making it—that account for the superiority of Rome products on a performance basis.

Experience proves merit

For example, miles of RoZone-RoPrene aluminum 5 KV and 600 volt auxiliary power cable have gone into the PG&E $80,000,000 Pittsburg plant.

At Niagara Mohawk about 110 miles of Rome RoLene insulated control cables and 41 miles of RoZone-RoPrene power cables were installed. *In both cases, these installations were preceded by other Rome installations.*

Confidence based on experience? Sure. Lots of it. RoZone is a premium quality oil base type of insulation which exceeds all requirements of ASTM specification D-574, *assuring unquestioned reliability.*

Ionization tested

It's resistant to corona action and aging. It shows high stability in water and has excellent dielectric characteristics. As a further safeguard, *every foot of Rome power cable rated at 3000 volts and over is subjected* to ionization testing as a standard manufacturing procedure . . . your safeguard of dependable performance.

And if you need any special constructions, Rome has the kind of research and engineering people who can win and hold your confidence. Your inquiry is welcomed.

NEW 45-minute sound color film "CABLE—PATHWAY OF POWER" now available for showings to technical personnel. For bookings, write to Rome Cable Corporation, Rome, New York.

Take a positive step toward eliminating the headaches and red tape connected with so many cable purchases. Rome's helpful, friendly service can benefit YOU. Fill in the reader-service slip below and mail it today.

- *Atlanta, Ga.
- Boston, Mass.
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- Detroit, Mich.
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- New York, N. Y.
- Philadelphia, Pa.
- Pittsburgh, Pa.
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ROME CABLE CORPORATION, Dept.EE-6, Rome, N. Y.
I am interested in the Rome Power and Control Cable Catalog.

Name..

Company..

Address..

City........................ Zone........ State............

(*Continued from page 36A*)

purpose component motor department. The new motor has aluminum end-shields, cast aluminum rotor, and welded steel shell for maximum strength. Formex (registered trade-mark of General Electric Company) insulated windings, plus slot and between-phase insulation of polyester film, provide extra protection against humidity and cellar dampness. The new dripproof motor, type *KH* (split phase), is equipped with drip-cover, built-in switch, and bottom flange for direct mounting. Rated at 1/3 hp, the motor is available in 50-cycle 1,425-rpm, and 60-cycle 1,725-rpm models, and 115/230 volts.

Vacuum Tube Voltmeter. A new high-accuracy vacuum-tube voltmeter covering all frequencies from 10 cycles per second to 4 mc is now being manufactured by the Hewlett-Packard Company. The new instrument, Model *400 D*, measures voltages from 0.1 millivolt to 300 volts and is accurate to within 2 per cent up to 1 mc. Input impedance is 10 megohms, so circuits under test are not loaded. The instrument has a new amplifier circuit providing approximately 56 db of feedback in mid-range for high stability and freedom from calibration changes caused by external conditions. For complete details write Hewlett-Packard Company, Department P, 395 Page Mill Road, Palo Alto, Calif.

Transistorized Fuel Gauge. Transistors have replaced vacuum tubes in a revolutionary new fuel-measuring system developed by the Aeronautical Division of Minneapolis-Honeywell Regulator Company. The system is approximately 75 per cent lighter, 86 per cent smaller, and uses less than half as much power as systems of comparable accuracy using vacuum tubes. Heart of the new system is Honeywell's own recently announced power-type transistor, the first ever built with enough power output to drive a fuel-measuring indicator through the required temperature range. Tests have proved that the new system will indicate accurately from −67 degrees F to +165 F. Because transistors have almost unlimited life, it has been possible to seal both the indicator and power unit hermetically in a single compact case.

TRADE LITERATURE

Alcoa Booklet. Sixty-five years of leadership in light metals research set the theme for "Research at ALCOA," a 54-page booklet just published by Aluminum Company of America. In addition to a description of the work of Aluminum Research Laboratories, the booklet provides a useful bibliography of technical articles about aluminum. A brief historical note precedes the first section which outlines the work of Alcoa's 14 research divisions. In the 40-page bibliographic section are

(*Continued on page 52A*)

(*Continued from page 48A*)

listed more than 1,000 books, technical papers, and articles prepared by Alcoa research scientists in the last 35 years. Copies may be obtained from Alcoa sales offices or from Aluminum Company of America, 726 Alcoa Building, Pittsburgh 19, Pa.

Farm Irrigation Bulletins. Two new publications on irrigation pumping have been announced as available from the General Electric Company, Schenectady 5, N. Y. One bulletin of eight pages, designated *GEA-5917B*, contains information on the selection and application of electric equipment for irrigation pumping, with photographs, drawings, and tables outlining the steps. Sections on maintenance, wiring, and operating details are included. The other bulletin, number *GEC-1023*, presents 20 pages of data on the various motors and controls used for irrigation pumping. Information on ratings, prices, operating characteristics, and dimensions are given.

Television Products. A new, revised 36-page bulletin listing the complete television broadcast products manufactured and distributed by Allen B. Du Mont Laboratories, Inc., is now available. The contents are classified and listed in an alphabetical index. Every product handled by the television transmitter department is itemized under three column headings: Model/Type, Description, and Price. The booklet can be obtained by writing to the television transmitter department, Allen B. Du Mont Laboratories, Inc., 1500 Main Avenue, Clifton, N. J.

Actuators Catalogue. A 64-page catalogue of electric actuators made by AIResearch Manufacturing Company has just been published. The booklet outlines the applications and specifications of 20 basic types of linear and rotary actuators, power units, jacks, gear boxes, and ammunition boosters. Illustrated with photographs, charts, and engineering drawings, the booklet is designed to help potential users choose the model that will suit their needs best. Copies are available from AIResearch Manufacturing Company, Los Angeles 45, Calif.

Low-Voltage Switchgear. A new 36-page booklet on low-voltage switchgear has been announced as available from the Continental Electric Equipment Company, Box 1055, Cincinnati 1, Ohio. The simplified format and presentation of text and illustrative matter make this catalogue easy to use and understand. It is a manual for every one interested in specification and application of low-voltage switchgear. Bulletin *200* may be obtained by writing to the manufacturer.

TV Distribution Systems. A new 32-page illustrated specifications book cover-

(*Continued on page 56A*)

(*Continued from page 52A*)

ing the planning of television distribution systems has been made available by Jerrold Electronics Corporation, Philadelphia, Pa. The advent of color television gives this specifications book special value to architects, engineers, contractors, and others concerned with the problems of designing, specifying, and supervising the installation of television systems. Such systems are used in various applications including apartment buildings, hotels, hospitals, schools, stores, and other places where a number of television receivers are to be served from one antenna array. The booklet is available at no charge to all interested professionsals. Requests should be mailed on business letterheads to: Jerrold Electronics Corporation, 26th and Dickinson Streets, Philadelphia 46, Pa.

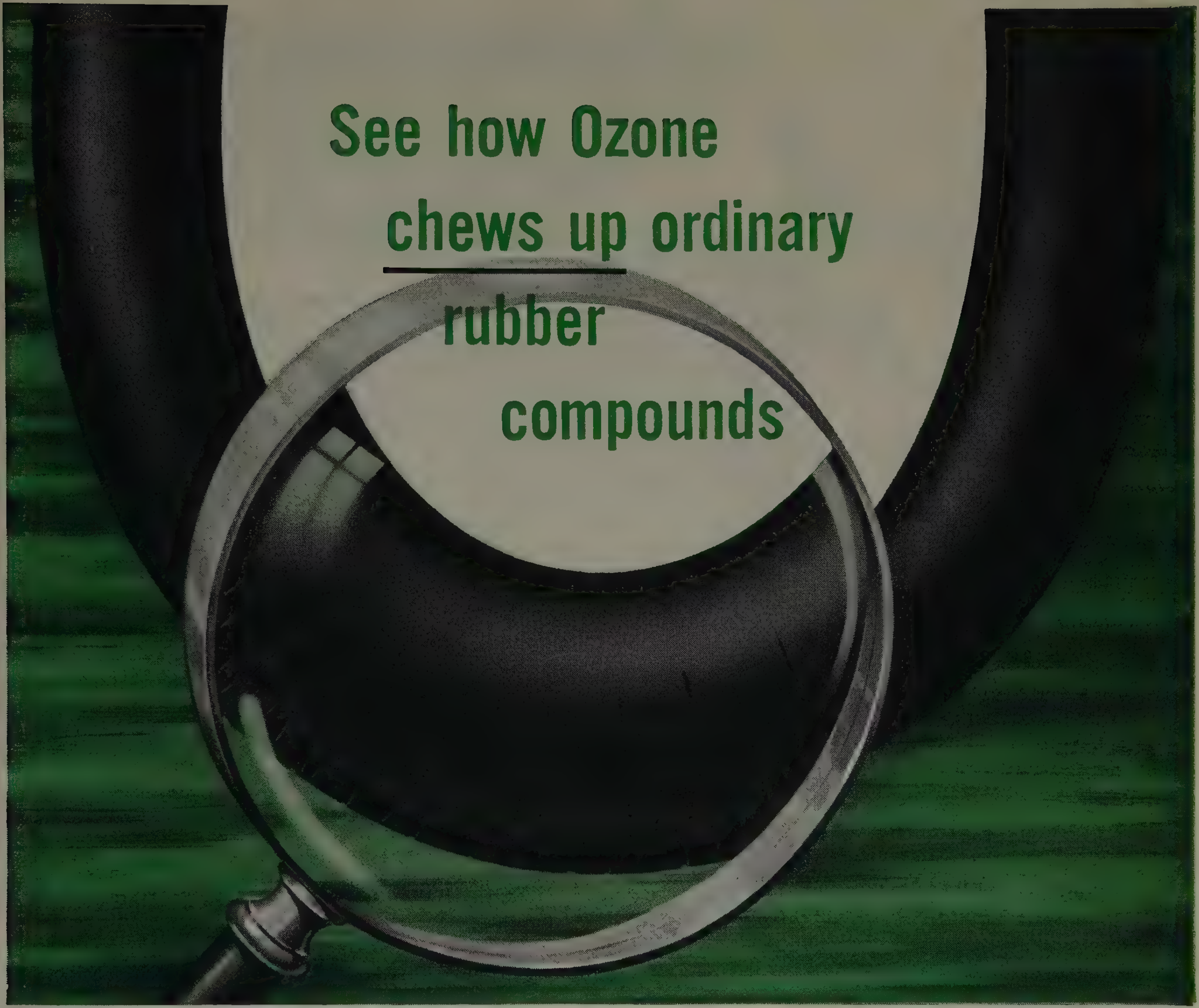
Gas Analyzer. Taller & Cooper, Inc., has announced a gas analyzer that is capable of indicating gas concentrations as low as five parts per billion. This analyzer uses the most sensitive method of analysis known, the detection of mercury vapor in ultraviolet light. Application is in air pollution surveys, and any factory or mine where measurement of gases on low concentration is necessary. For copies of the bulletin describing this instrument write to Taller & Cooper, Inc., 75 Front Street, Brooklyn 1, N. Y.

Selenium Rectifier Handbook. Sarkes Tarzian, Inc., Rectifier Division of Bloomington, Ind., has just published a new selenium rectifier handbook. This 72-page 3-color booklet contains much engineering information in demand today. The revised selenium rectifier replacement guide has been included in this publication. Different types of selenium rectifiers are treated in detail in separate sections of the book. Many suggestions for applications and a wealth of engineering data round out the handbook. It retails for $1.00; however, the manufacturer will send the booklet to readers of *Electrical Engineering* free of charge on request.

Rowan Offers Control Booklet. The Rowan Controller Company of Baltimore, Md., has announced as available their 20-page booklet that describes the company's line of industrial electric motor control. The booklet is profusely illustrated and contains much helpful data on the company's controls. Write to The Rowan Controller Company, 2313–2315 Homewood Avenue, Baltimore 18, Md., for copies.

Flexible Shafts and Couplings. Catalogue Number *5494*, containing information relating to the design and use of flexible shafts and couplings, is being offered by the Kupfrian Manufacturing Company, 395 State Street, Binghamton, N. Y. Included in the catalogue is a complete table of the physical properties of two dozen different flexible shafts ranging in size from 1/8 to 3/8 inch. A similar table lists 29

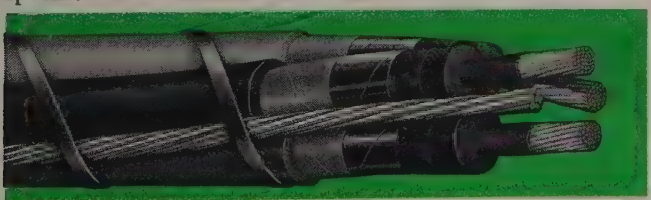
(*Continued on page 62A*)



but not U. S. Grizzly Uskorona-insulated power cables

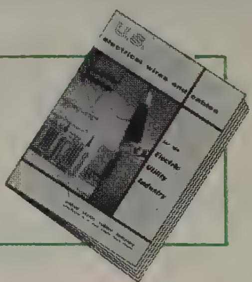
Here's an illustration showing how ozone can chew up a sturdy, rugged cable. This can never happen with United States Rubber Company's famous Grizzly® power cables, insulated with Uskorona® compound which prevents electrical failure caused by ozone (Uskorona-1 oil base compound and Uskorona-2 butyl base compound). Uskorona meets (and in many ways exceeds) the applicable IPCEA specifications for ozone-resistant rubber insulation.

U. S. Grizzly ozone-resistant power cables are typical of the wires and cables "U. S." develops to meet the ever-increasing rate of expansion of electrical generation and construction. "U. S." is always ready with new products to meet new demands and is always developing, as a matter of policy, wires and cables that are more economical because they are more serviceable.



U. S. Grizzly Uskorona-insulated Power Cable, 15,000 volts, Type RR, 3 conductor, shielded, Neoprene jacket

Send for free illustrated book giving full information about U. S. Electrical Wires and Cables for the Electric Utility Industry.



UNITED STATES RUBBER COMPANY

ELECTRICAL WIRE & CABLE DEPARTMENT, ROCKEFELLER CENTER, NEW YORK 20, N. Y.

(*Continued from page 56A*)

different flexible shaft casings. Illustrated also in full scale are over 30 standard flexible shaft couplings and assemblies. Requests for this catalogue should be directed to the manufacturer.

Modern Voltage Regulator Practice Booklet. Because of the constantly increasing requirements for close voltage control, coupled with rapid load growth, the Westinghouse Electric Corporation has made available a 20-page booklet on modern regulator practice. Fundamental application factors of step and induction voltage regulators are discussed, and charts are used to show graphically what popular practice is today. Both types of regulator are compared from the standpoints of maintenance characteristics and the speed of response factor. Full lines of station and pole-type regulators, both step and induction design, are described. For a copy of booklet *B-6053*, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Automatic Transfer Switch. In publication number *502*, "Automatic Transfer Switches," recently issued by the Automatic Switch Company, Orange, N. J., factors to look for in selecting an automatic transfer switch are described in detail. This booklet should be very helpful to those responsible for selecting automatic transfer switches, and for installing, connecting, and maintaining emergency lighting and power sources. Written in concise language, and including necessary wiring diagrams and photographs, the booklet is available from the manufacturer.

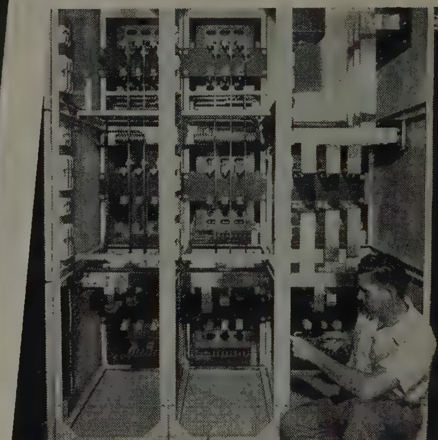
Germanium Crystals. Sylvania Electric Products, Inc., has announced the publication of a new 42-page booklet entitled, "Industrial Uses for Germanium Crystals." Realizing that there are many applications of germanium crystals which are of particular use to industry and of only secondary interest to the communications worker, the new booklet is devoted entirely to industrial application. The four main chapters in this booklet cover: relays and relay applications; timing circuits; power supply applications; and applications to industrial instrumentation. The booklet is priced at 25¢ and may be obtained by writing to Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

Station-Type Arresters. A new 28-page 2-color bulletin on station-type arresters has been announced as available from the General Electric Company, Schenectady 5, N. Y. Designated as *GEA 1304L*, the booklet describes the operation and design of a new Thyrite (registered trade-mark of the General Electric Company) magnevalve arrester that combines magnetic action and valve action. Application information and a guide for selection of

(*Continued on page 64A*)

OUR FACTORY!

No. 2 in a series of pictorial tours thru the Nelson Plant showing Nelson Electrical Equipment "in the making."



Wire harness is being connected to rear terminal blocks by this experienced workman. Assembly shown is rear view of Nelson Class 722, Low Voltage, Metal-Enclosed, Air Circuit Breaker Drawout Switchgear.

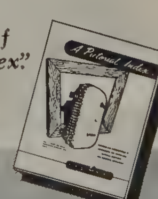
❶ Top photograph shows hinge cable being run from cubicle to instrument door of Nelson Class 726, Standardized, Vertical Lift, Metal-Clad, Oil Circuit Breaker Switchgear.

❷ The excellent performance of Nelson Class 1035 Motor Control Centers is assured at our factory where each wiring operation is given scrupulous attention as shown above.

This Nelson inspector is carefully checking continuity of control circuit in Class 423, Explosion-Proof, Two-Speed, Combination Motor Starter.

MANUFACTURERS OF: Instrument and Control Panels • Benchboards and Consoles • "Centrol" Motor Control Centers • Switchgear—low voltage and high voltage • Unit Substations • Motor Starters, Circuit Breakers, Lighting Panels, Control Stations and Junction Boxes in water-tight, dust-tight and explosion-proof enclosures • "Nelex" Mineral Insulated Heater Units

Write for a copy of our "Pictorial Index."



NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

(*Continued from page 62A*)

arrester ratings are provided in the illustrated publication.

Distribution Transformers. The Standard Transformer Company, Warren, Ohio, has released a new descriptive bulletin on *OISC* distribution transformers with built-in surge and overload protective devices. Data and photographs on sizes through 100 kva and ratings through 14,400 volts are included. Write for Bulletin *S-302A*.

Mark Instrument Booklet. A 4-page booklet describing the new miniaturized induction resolvers, induction potentiometers, integrating tachometers, arbitrary function-generators (voltage or torque versus angle of shaft rotation), has been published by the Mark Instrument Company, Inc., 613 Wilshire Boulevard, Santa Monica, Calif. Also included is information on precision hardware, equipment, and systems to customer order.

New Movie Released by Raytheon. "Ready for Sea," a new color motion picture depicting the production and grueling tests of electronics equipment for use on board ship, has been released by the Raytheon Manufacturing Company. The 16-millimeter sound film runs 13 minutes. It features the colorful and dramatic phases of the design, production, and testing program carried out by the Waltham, Mass., electronics firm in conjunction with its new model *1500* "Mariners Pathfinders" radar. The movie shows how this all-seeing eye, designed to guide small vessels, tugs, yachts, etc., through dark of night or fog and storm, is made. The scenes include the environmental test laboratory, where products are put through their paces under the torture of freezing cold, searing heat, inclination, air-hammering, impact, vibration, drip, and salt spray. The film may be booked for group showings through the public relations department, Raytheon Manufacturing Company, Waltham 54, Mass.

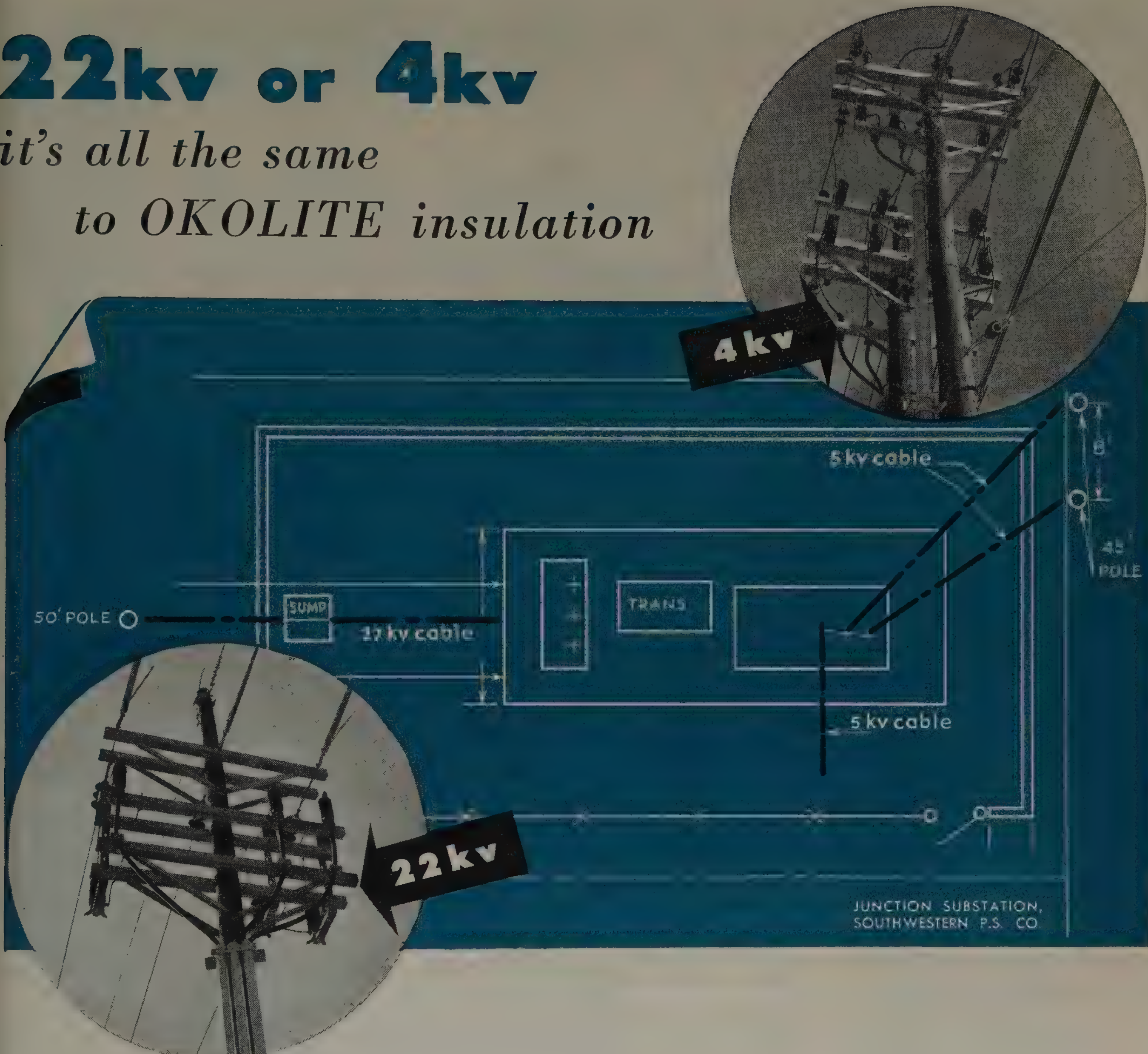
Oscillograph Booklet. A 12-page bulletin describing the Du Mont Type *323* wide-band cathode-ray oscillograph has just been published by the Instrument Division of Allen B. Du Mont Laboratories, Inc. The new booklet gives complete specifications about the instrument and contains illustrations and circuit diagrams. It is available upon request from the technical sales department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J.

Weatherproof Wire. A new type of weatherproof wire, in which the outer braid is glass yarn, has been announced by the Rome Cable Corporation of Rome, N. Y. This new glass-covered wire is available in triple knit weatherproof wire, in sizes number 14 through 4 American Wire Gauge in a special wholesaler's 500-foot coil package. The glass outer braid is inherently resistant to moisture, heat, chemical action, and abrasion.

22kv or 4kv

it's all the same

to OKOLITE insulation



High voltage or low voltage—Okolite rubber insulation provides maximum dependability and utmost safety. Here at the Junction Substation of the Southwestern Public Service Company in Lubbock, Texas, both the 4kv and 22kv circuit risers are Okolite-insulated, Okoprene-sheathed cables.

Okolite-Okoprene cables have an outstanding reputation for reliability in circuits up to 35,000 volts. Okolite-Okoprene is easy to handle and cuts installation costs; the problem of oil migration is non-existent and splices and terminations require less time and labor.

Write today for Okonite's complete handbook on rubber-insulated, high-voltage cables, Bulletin EG-1075. It contains complete engineering and installation information for circuits up to 35,000 volts. The Okonite Company, Passaic, N. J.

OKONITE OKONITE SINCE 1878 ***insulated cables***

OKONITE PASSAIC, N.J.

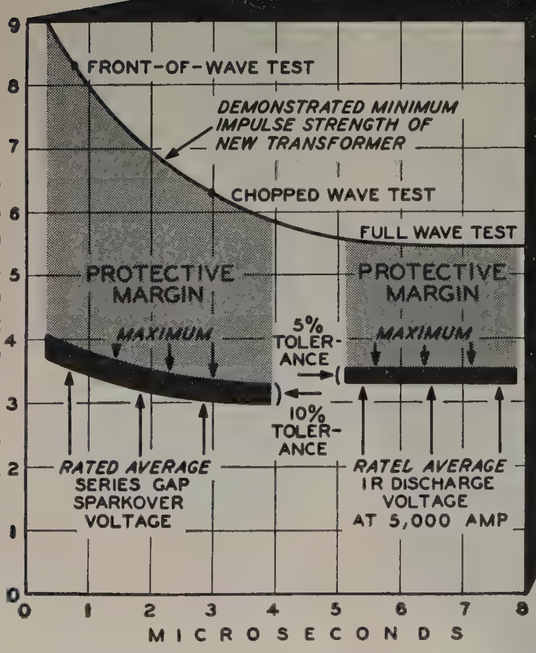
2304

It's a matter of PLAIN PROTECTION!

In the final analysis, a lightning arrester is just as good—and no better—than the protection it provides. And putting the Thorex story in a nutshell, this arrester gives you *both* the greatest protection per dollar, as well as the greatest protection regardless of price!

For the safety of primary loads and major equipment, and for maximum assurance of adequate Protective Margins,* your soundest lightning arrester choice, today, is the O-B Thorex.

**Protective Margin, as illustrated in this typical application curve, is that zone existing between MAXIMUM arrester protective rating (tolerance added to average rating) and minimum insulation strength of equipment.*



Ohio Brass

MANSFIELD OHIO, U.S.A.

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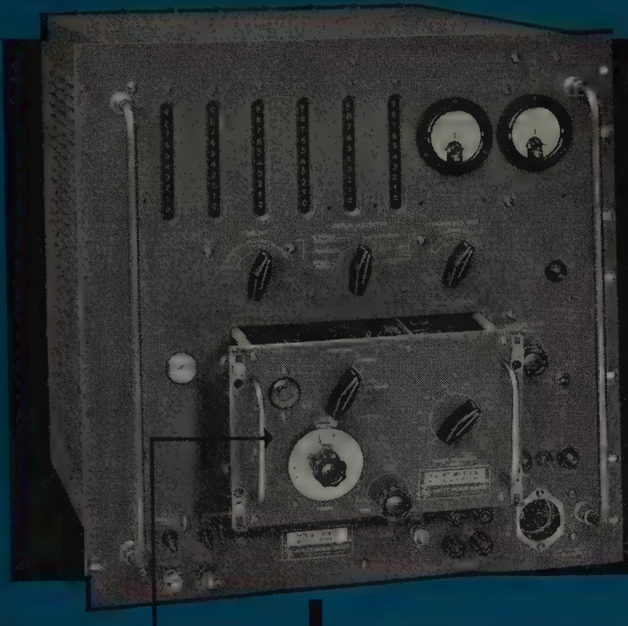
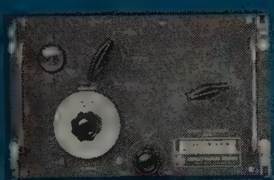
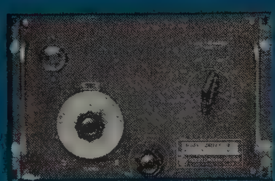


Frequency 10 cps to 220 mc
Interval 1 µsec to 100 days
Period 0 cps to 10 kc

measured instantly, automatically, directly by the revolutionary new...



-hp- 525A
Frequency Converter



-hp- 525B
Frequency Converter

-hp- 526A
Video Amplifier

-hp- 526B
Time Interval Unit

-hp- 524B ELECTRONIC COUNTER

Why buy more instrumentation than you need? The new all-purpose *-hp-* 524B Electronic Counter with Plug-In Units gives you *precisely* the frequency, time interval or period measuring coverage you want now. Later, you can add other inexpensive plug-in units to double or triple the usefulness of the Counter.

Model 524B offers direct, instantaneous, automatic readings requiring no calculation, interpolation or complex instrument set-up. It has high sensitivity, high impedance, and its operation is so simple and dependable it can be used readily by non-technical personnel. Resolution is 0.1 µsec, and accuracy is 1/1,000,000 ± 1 count. Construction throughout is of highest quality components in a compact militarized design.

The new Counter with Plug-In Units gives you more range, more convenience, smaller size and lower cost than any commercial instrument combination ever offered. With this one compact equipment, you readily measure transmitter and crystal oscillator frequencies, time intervals, pulse lengths, repetition rates, frequency drift; make high accuracy ballistics time measurements or high resolution tachometry measurements, or use as a precision frequency standard giving convenience and flexibility not provided in the usual primary standard.

Data subject to change without notice. Prices f.o.b. factory

BASIC COUNTER

The basic *-hp-* 524B Counter unit measures frequency from 10 cps to 10 mc with accuracy of ± 1 count ± stability, reading direct in kc; or measures period from 0 cps to 10 kc with accuracy of ± 0.3% reading direct in seconds, milliseconds or microseconds. Eight-place registration, short term stability 1/1,000,000, display time variable 0.1 to 10 seconds. $1,890.00

COUNTER WITH PLUG-IN UNITS

-hp- 525A Frequency Converter extends Counter's range to 100 mc, maintains accuracy, and increases Counter's video sensitivity to 0.1 volts through basic 10 cps to 10 mc range. $225.00

-hp- 525B Frequency Converter like 525A but extends Counter's range from 100 to 220 mc at 0.25 volts sensitivity. $225.00

-hp- 526A Video Amplifier increases Counter sensitivity between 10 cps and 10 mc to 10 millivolts for low level frequency measurement. $125.00

-hp- 526B Time Interval Unit measures interval 1.0 µsec to 100 days with accuracy of 0.1 µsec ± 0.001%, reading direct in seconds, milliseconds or microseconds. Start, stop triggering in common or separate channels, through positive or negative going waves. $150.00 (Plug-in units supplied in aluminum storage case).

Request complete details today from your -hp- Field Representative, or write direct

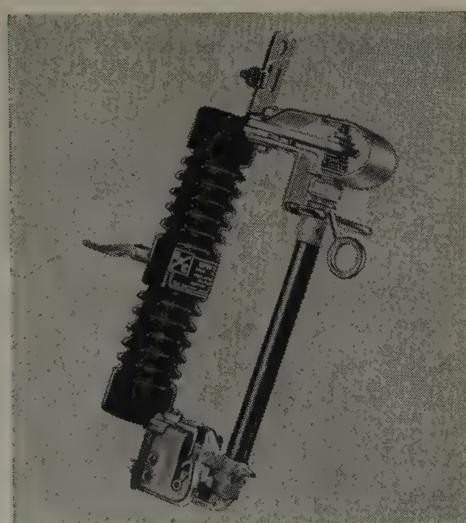
HEWLETT-PACKARD COMPANY
2998E Page Mill Road • Palo Alto, California, U. S. A.

hp INSTRUMENTS | COMPLETE COVERAGE

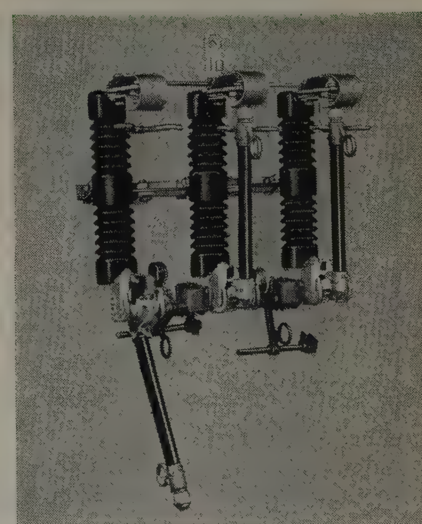
MODERN IN CONCEPT

MODERN IN DESIGN

MODERN IN APPLICATION



S&C TYPE XS CUTOUT
single-shot, birdproof



S&C TYPE XS CUTOUT
three-shot, birdproof

THE TYPE XS CUTOUT

offers added advantages by eliminating:

√ the time-consuming operation of short-circuit zoning analysis to determine whether a standard-duty or a heavy-duty cutout is needed in each particular location.

√ ordering or stocking two types.

√ carrying two types of cutouts in service trucks.

√ the worry about construction crews installing the wrong cutout or tube at protection points.

Complete information on the Type XS Cutout is contained in new Catalog Section 511 . . . we will gladly send you a copy.

S&C ELECTRIC COMPANY

4427 RAVENSWOOD AVENUE
CHICAGO 40, ILLINOIS, U. S. A.

IN CANADA:
S & C ELECTRIC CANADA, LTD.
8 Vansco Road, Toronto 14, Ontario

POWER FUSES • DISTRIBUTION CUTOUTS AND FUSE LINKS • LOAD INTERRUPTERS • METALCLAD SWITCHGEAR

Specialists in High-Voltage Circuit Interruption

IT'S HERE! *the* R&IE

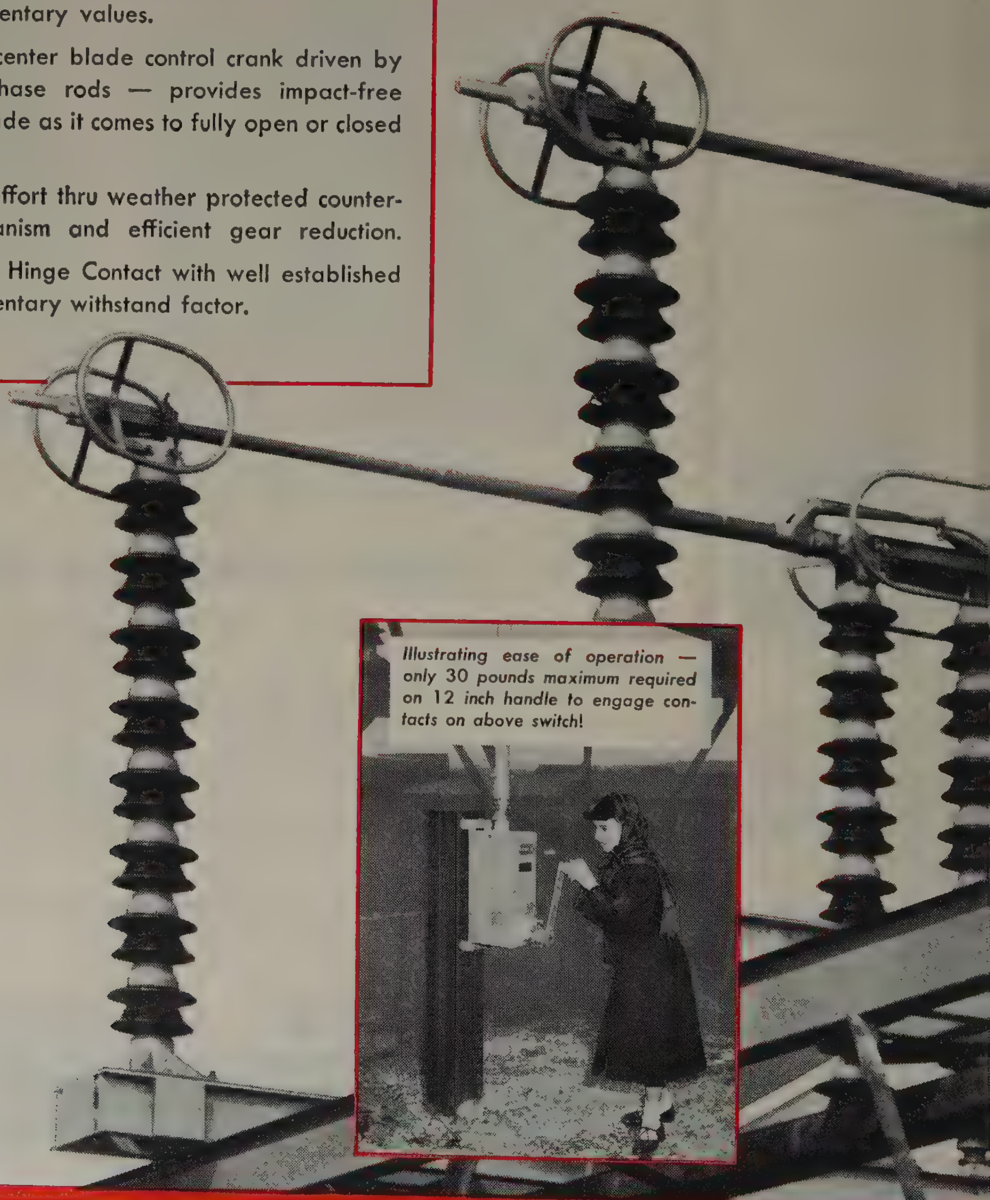
with 5 EXCLUSIVE features - -

1. Corona free at 300 Kv to ground with switch closed and 275 Kv to ground with switch open — with less than 500 micro volts radio influence. Best R. I. V. test performance of any switch to date.
2. Only ONE exposed contact. — Hi-Pressure, plus blade rotation, equals self-cleaning. Straight line current path thru break contact — an advantage providing extra high momentary values.
3. Accurate dead center blade control crank driven by Torsional Interphase rods — provides impact-free movement of blade as it comes to fully open or closed positions.
4. Low operating effort thru weather protected counter-balanced mechanism and efficient gear reduction.
5. Sealed Pressure Hinge Contact with well established extra high momentary withstand factor.

In addition to the many other outstanding design features that characterize

R&IE Switches

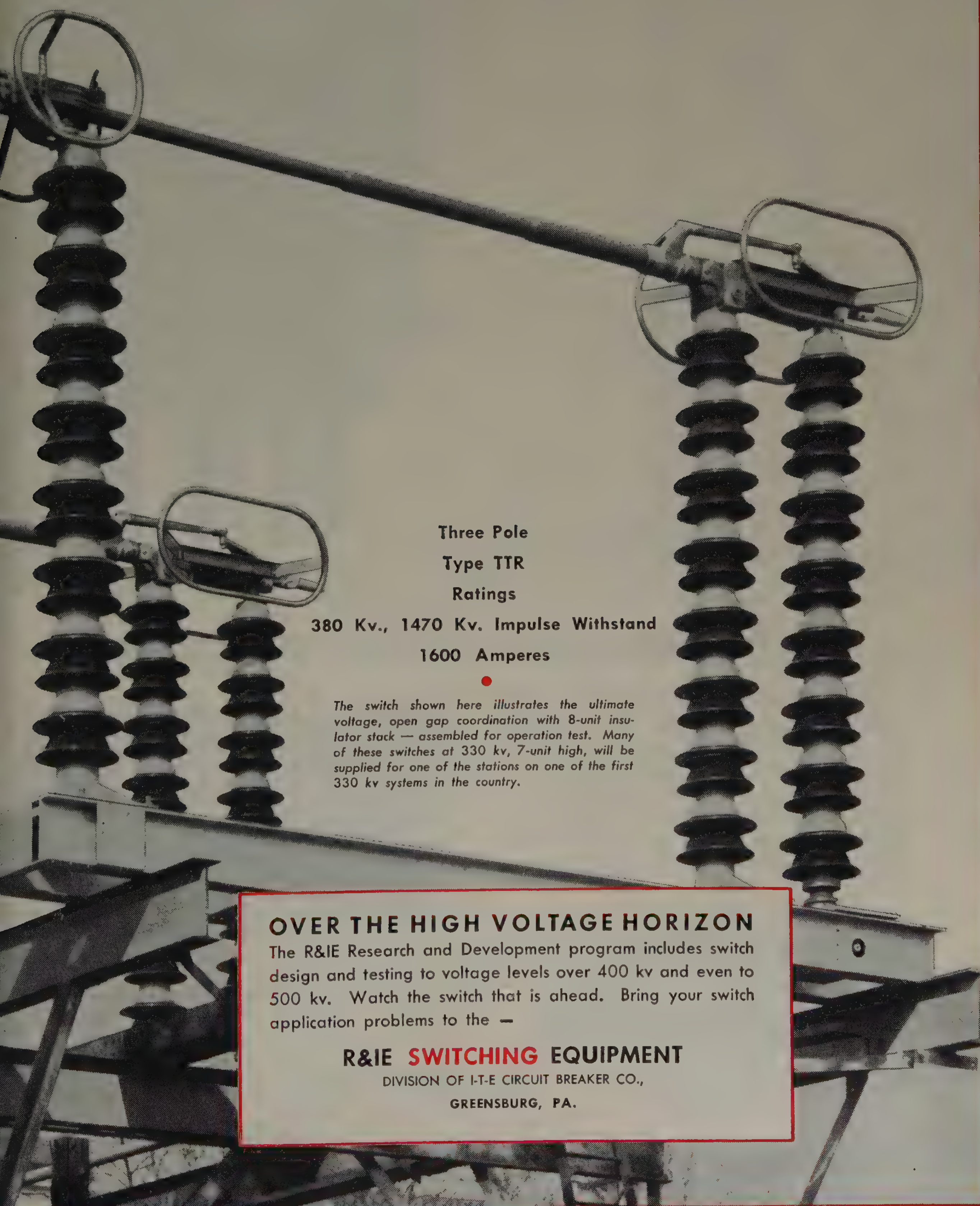
Compare these Facts



Illustrating ease of operation — only 30 pounds maximum required on 12 inch handle to engage contacts on above switch!

FORTY-THREE YEARS OF PIONEERING FOR THE ELECTRICAL INDUSTRY

380 Kv AIR SWITCH



SPLITTING HAIRS

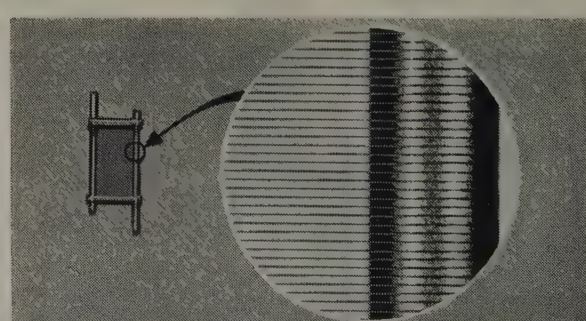
TO SPEED CALLS

This coaxial system electron tube amplifies more voices at the same time because of wider frequency band—made possible by bringing grid and cathode closer together.

To triple the voice-carrying capacity of coaxial cable, Bell Laboratories engineers had to create new amplifying tubes with the grid placed only two-thirds of a hair's breadth from the cathode. Furthermore, the grid wires had to be held rigidly in position; one-quarter of a hair's shifting would cut amplification in half.

Working with their Bell System manufacturing partners at Western Electric, the engineers developed precise optical means for measuring critical spacing insulators. On a rigid molybdenum grid frame they wound tungsten wire three ten-thousandths of an inch thick. To prevent the slightest movement they stretched the wire under more tension for its size than suspension bridge cables, then bonded it to the frame by a new process.

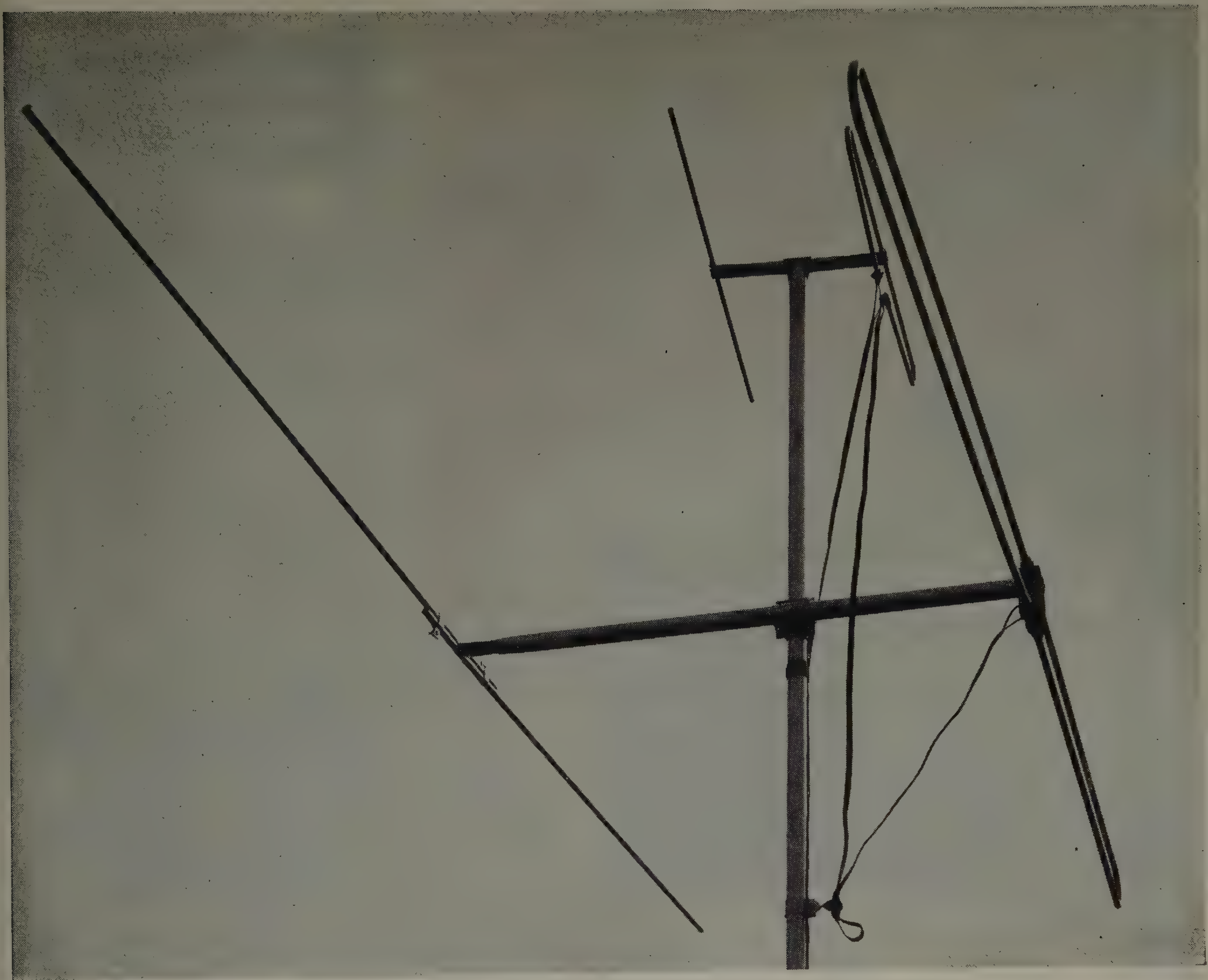
The resulting tube increases coaxial's capacity from 600 to 1800 simultaneous voices—another example of how Bell Telephone Laboratories research helps keep your telephone system growing at the lowest possible cost.



Grid is shown above left, actual size. Picture at right, enlarged 15 times, shows how wires are anchored by glass bond. They will not sag despite nearness of red-hot cathode.

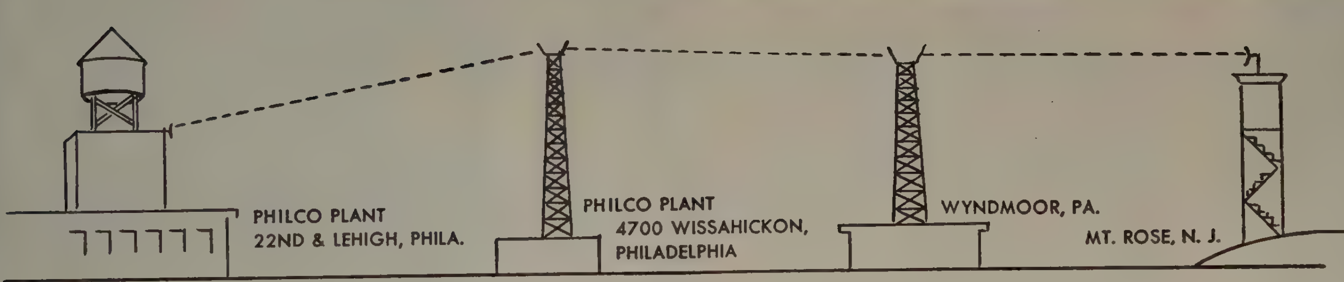
BELL TELEPHONE LABORATORIES

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS
FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS



PHILCO "PROVING GROUND" FOR MICROWAVE

Philco 160-foot microwave tower at 4700 Wissahickon . . . one of four similar Philco test sites in the Philadelphia area.



To supply industry's mounting demand for modern, efficient and private communications which do not depend on vulnerable wire lines, Philco is installing thousands of miles of new microwave for oil and gas pipelines, utilities, railroads and other major industries. Constantly improving the performance and reliability of Philco microwave equipment, each newly designed component and equipment is field tested and perfected on Philco's experimental microwave system . . . the equivalent of a 70-mile commercial installation . . . Another reason why Philco Microwave leads the field in quality, performance and reliability . . . Good reason why Philco is the world's leading manufacturer of microwave equipment.

PHILCO Famous for QUALITY the World Over

PHILCO CORPORATION

GOVERNMENT & INDUSTRIAL DIVISION • PHILADELPHIA 44, PA.

LOOK TO THE RECORDS FOR LOWEST COST WITH NATIONAL BRUSHES

TRADE-MARK

ENGINEERS!

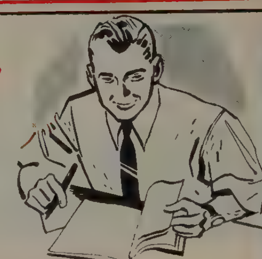
Their wide-range applicability reduces the number of items needed for your plant. You do an even *better* job with fewer brushes. *Lower cost to you!*

MAINTENANCE MEN!

By maintaining proper commutator film and surface, "National" brushes reduce commutator maintenance, provide superior commutation and last longer. *Lower cost to you!*

PURCHASING AGENTS!

More stock and catalog brushes than any other brand ... minimizes costly short-run items. Quicker delivery and, again, *lower cost!*



STOREKEEPERS!

Sturdy, light-weight, easy-to-identify packaging aids good house-keeping, saves time in requisitioning. All add up to *lowest cost, most efficient operation.*

Use "National" brushes on your main-drive, mill-type and general-purpose motors. Then watch the records spell out unmistakably better performance, better services of supply and the lowest overall brush cost you've ever enjoyed.

The term "National", the Three Pyramids device, and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

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A Division of Union Carbide and Carbon Corporation

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District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

IN CANADA: Union Carbide Canada Limited, Toronto

How good is really good brush performance? Use "National" brushes and see!

NATIONAL STANDARDIZED BRUSHES

BETTER—PRODUCT—PACKAGE—PRICE—FASTER

This is a unit similar to thousands which have been made. Not always, however, has a manufacturer been able to undertake a production schedule of such pieces with assurance of a high percentage of yield of sound pieces, as can we at Lapp today.

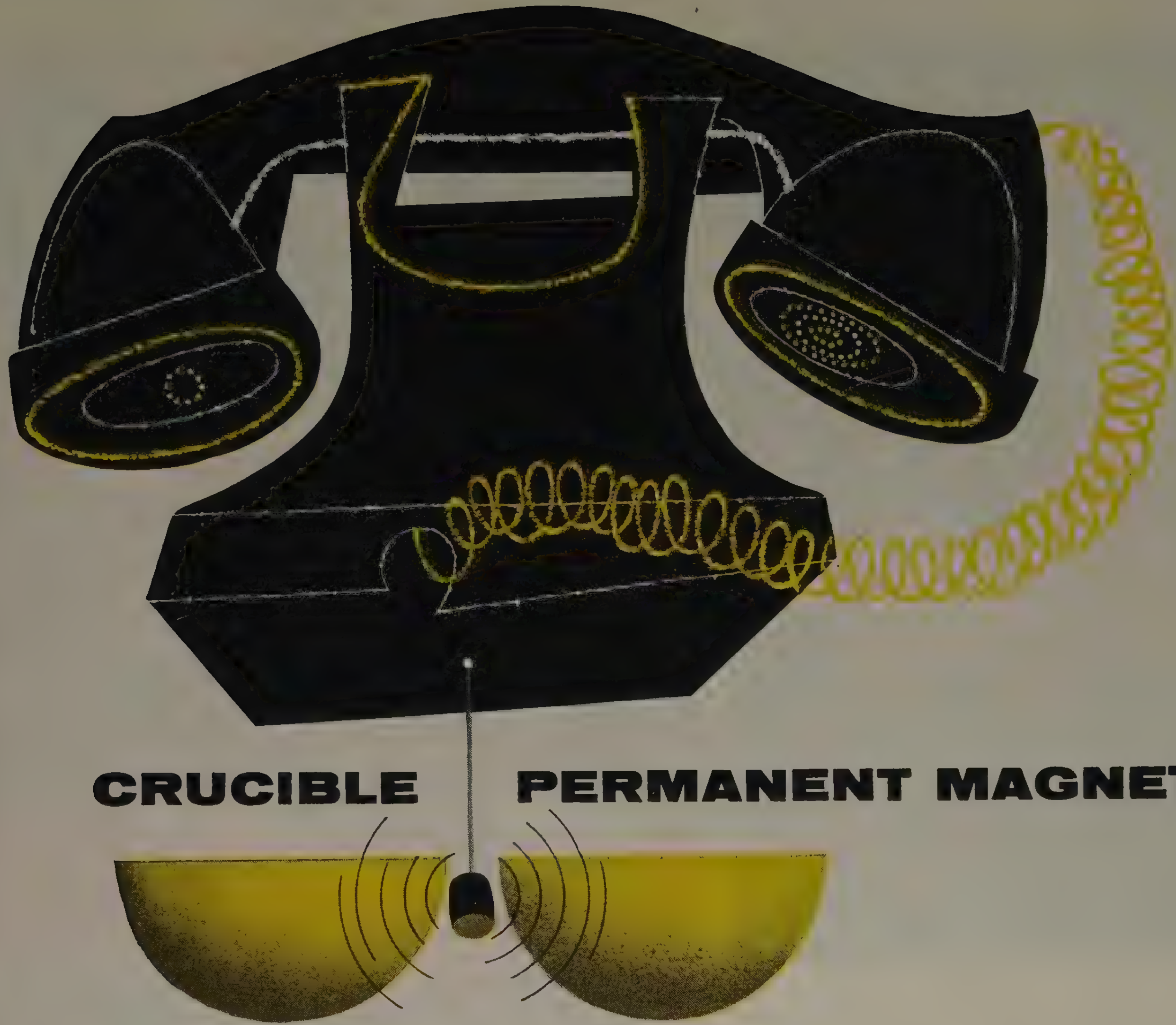
And we have known of more than one instance in the past when the energizing of important power plants depended on delivery to the job of bus supports of this type on schedule.

As an insulator it consists of a heavy malleable iron base, and a large malleable iron insert cemented into the top of the porcelain. The porcelain itself is H-shape in section, with massive walls and integral diaphragm.

Such thick sections are difficult of drying and firing, because of shrinkage—about 30% from plastic state to fired piece. Throughout manufacture, this shrinkage is insistent, and—except under critically controlled production techniques—unpredictable.

For 35 years Lapp has directed its attention and effort to the development of methods for producing *sound* porcelain to meet a varied range of requirements. The result is a quality of porcelain that provides an extra margin of operating security and extra value. When you buy electrical equipment—or insulators—look for the name LAPP on the porcelain. You'll be money ahead in the fact that although *you can buy cheaper porcelain . . . you can't buy better porcelain . . . than Lapp.* Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp



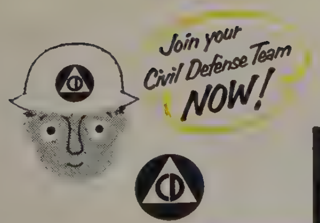
CRUCIBLE PERMANENT MAGNETS

provide maximum energy . . . minimum weight

No matter what your permanent magnet application may be — galvanometer, speedometer, television or telephone — you'll find that Crucible alnico magnets have a *consistently higher* energy product. This means more energy from a smaller magnet.

Since alnico alloys were first developed, Crucible has been a leading producer of this superior type of permanent magnet. And Crucible alnico permanent magnets are made by the nation's foremost specialty steelmaker.

For alnico magnets that are unsurpassed in quality — *call Crucible.*



CRUCIBLE first name in special purpose steels

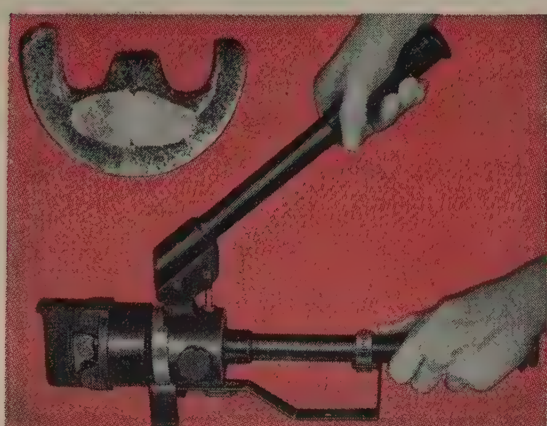
54 *years of Fine steelmaking*

ALNICO PERMANENT MAGNETS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

New, Powerful, DYNA-CRIMP tool features fast positive crimping action and easily-opened swivel head. Crimping heads can be changed easily. AMP DYNA-CRIMP tool gives maximum portability with remote control operation. Interchangeable dies are available for use with AMP's complete line of terminals for Aluminum wire, AMPLI-BOND, or SOLISTRAND Terminals. Shown above with moveable cart to transport power unit providing maximum flexibility for Bench-Production line use.



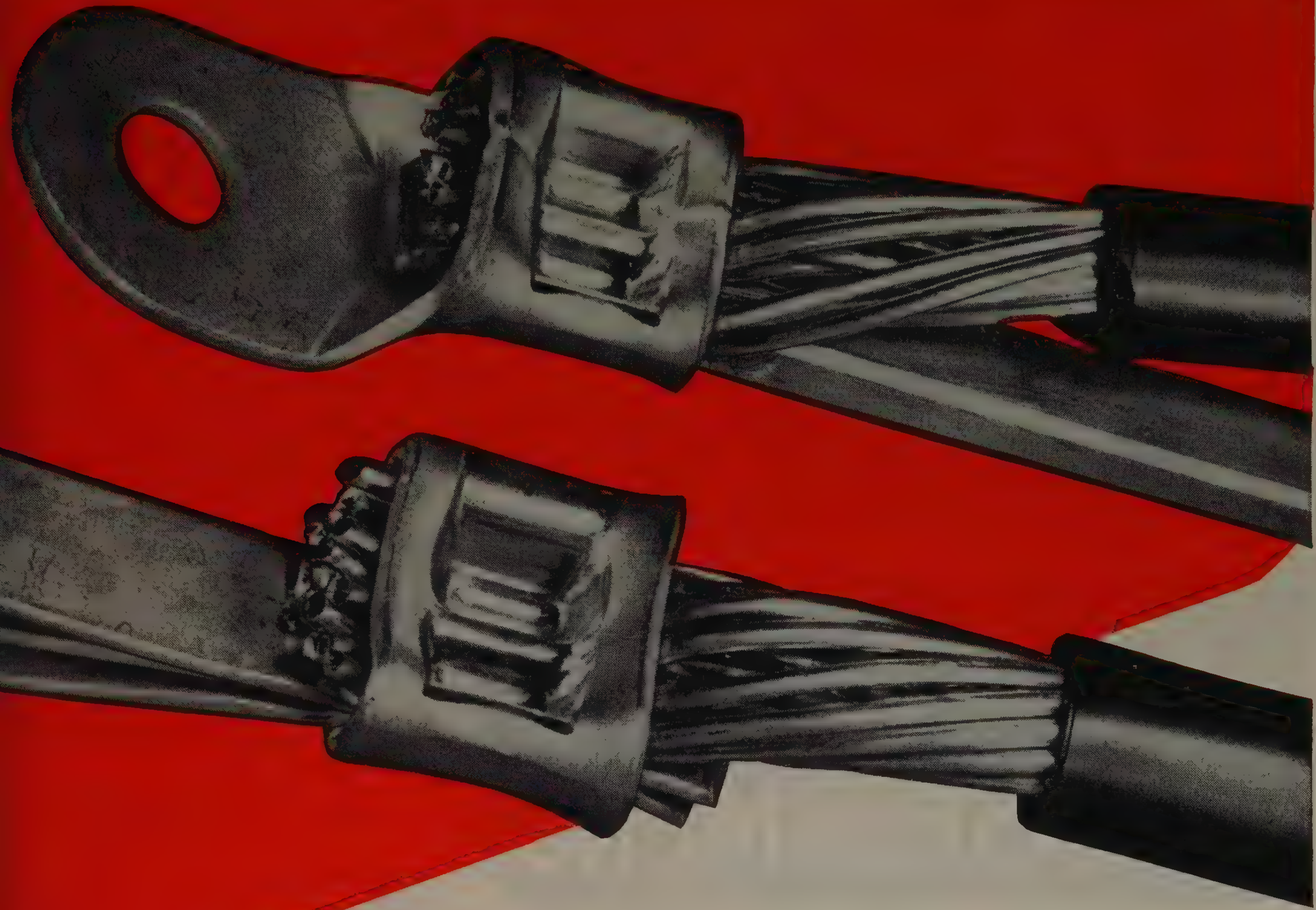
Cross section of AMP SOLISTRAND terminal shows the longitudinal indents which are characteristic of this crimp. Note cross section which presents the smooth, homogeneous appearance of one solid piece of metal. Tool shown here is AMP's hand hydraulic pump-type tool.

AMP

SOLISTRAND TERMINALS NOW UP TO 600,000 CIRCULAR MILS!

Find out about the New AMP "CREATIVE APPROACH TO BETTER WIRING"

. . . An evaluation survey without cost or obligation.



AMP "SOLISTRAND" terminals, strongest and best of all non-insulated solderless connectors, are now available in wire ranges up to 600,000 circular mils! Patented AMP "W" Crimp unites all conductors into a homogeneous, corrosion resistant mass with the terminal barrel. Optimum electrical and mechanical performance is assured through AMP's pre-determined crimp formula. Short barrel lengths, brazed seam construction, and reinforced tongue, all contribute to make AMP SOLISTRAND terminals the outstanding permanent splice or connection for solid, stranded, irregular shaped, or combinations of these wire types.

AMP precision-engineered crimping tools are available for all wiring requirements. Each tool from the smallest hand tool to the powerful new DYNA-CRIMP pneumatic-hydraulic crimping unit (see left), is designed to produce uniformly high quality terminations with ease, precision, and efficiency. Write today for information and samples.

AIRCRAFT-MARINE PRODUCTS, INC.
2100 Paxton Street Harrisburg, Pennsylvania
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AMP

Transmission Towers

designed to carry any load ...to fit any terrain!

Recent high voltage line towers by AMERICAN BRIDGE

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Ohio Power Company
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Dayton Power and Light Company
Cincinnati Gas & Electric Company
Detroit Edison Company
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Idaho Power Company
Indiana & Michigan Electric Co.

AMERICAN BRIDGE steel towers carry many thousands of circuit-miles of transmission lines across this great land. Scaling the heights of rugged mountains; through marshy lowlands, traversing every conceivable kind of terrain, these steel transmission towers are helping make America's great power distribution system the world's best.

American Bridge towers are made to order for every type of transmission line service. They are designed for simplified erection on level, side-hill, or rocky butte sites. They are engineered for heavy-duty service under the severest climatic conditions.

Incorporating special design features such as steel grillage earth anchors and variable leg extensions, American Bridge towers make possible important savings in time, labor, and material costs.

The technical knowledge and experience American Bridge has acquired in more than fifty years of designing, fabricating and erecting towers may be just the answer to your problems. Our engineers welcome an opportunity to figure on your requirements. Just write our nearest office.

AMERICAN BRIDGE DIVISION, UNITED STATES STEEL CORPORATION
GENERAL OFFICES: 525 WILLIAM PENN PLACE, PITTSBURGH, PA.

Contracting Offices in: AMBRIDGE · ATLANTA · BALTIMORE · BIRMINGHAM · BOSTON · CHICAGO · CINCINNATI · CLEVELAND · DALLAS · DENVER · DETROIT · ELMIRA · GARY · MEMPHIS · MINNEAPOLIS · NEW YORK · PHILADELPHIA · PITTSBURGH · PORTLAND, ORE. · ROANOKE · ST. LOUIS · SAN FRANCISCO · TRENTON   UNITED STATES STEEL EXPORT COMPANY, NEW YORK

AMERICAN BRIDGE

USS TRADE MARK

UNITED STATES STEEL

VHF

... Very High Frequencies

RADIO INTERFERENCE and FIELD INTENSITY* measuring equipment

Stoddart NM-30A • 20mc to 400mc

Commercial Equivalent of AN/URM-47

PRINTED CIRCUITRY... Modern printed circuits offer many advantages over conventional wiring, lighter weight, more compact units and freedom from many of the troubles normally encountered in conventionally-wired electronic equipment. Vibration becomes even less of a problem with printed circuits, adding to the many portable features already available with Stoddart equipment.

ADVANCED DESIGN... Specialized engineering and modern production techniques have produced one of the most advanced instruments for the accurate measurement, analysis and interpretation of radiated and conducted radio-frequency signals and interference ever manufactured. Designed to laboratory standards, rugged, and with matchless performance, the versatile NM-30A is an outstanding example of modern instrumentation. Its frequency range includes FM and TV bands.

SMALLER SIZE... A wider frequency range and higher standard of performance is incorporated into an equipment whose size is one-third that of any similar equipment ever manufactured.

SENSITIVITY... Sensitivity ranges from one to ten microvolts-per-meter, depending upon frequency and antenna in use.

APPLICATIONS... Field intensity surveys, antenna radiation pattern studies, interference location and measurement for checking radiation from virtually any mechanical or electrical device capable of generating or radiating radio-frequency signals or interference.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-6B. Very low frequencies.

HF NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.

UHF
NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17. Frequency range includes Citizens band and UHF color TV band.

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... FOR EVERY REQUIREMENT IN THE ELECTRICAL FIELD

Our Record: Over 50 years of progressive galvanizing service to manufacturers and fabricators of iron and steel products ... any size or shape, any size order from the smallest to the largest. *Excellent facilities for pickling and oiling.*

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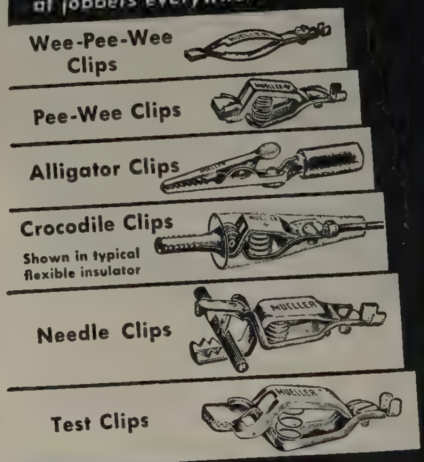
Mueller MAKES THE CLIPS!

ALL TYPES—ALL SIZES
at jobbers everywhere



SAMPLE BOARD

SEND FOR FREE CLIP & INSULATOR SAMPLES!
Pick from illustrations above.

5 INSULATOR COLORS now available for easy lead identification. Black, Red, White, Blue and Yellow. Samples furnished on request.

NEW CATALOG No. G557 ON REQUEST

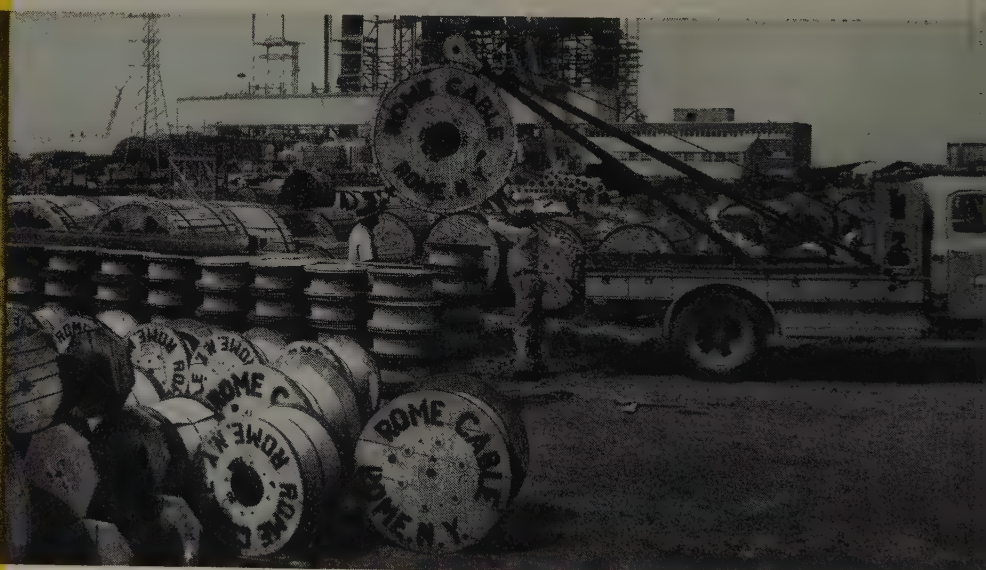
Ask about handy, low cost display and selection board, for department heads, jobbers, etc.

Mueller Electric Co.
1557G EAST 31st STREET • CLEVELAND 14, OHIO

The neatness of Rome thermoplastic control cables permits compact installations. They may be installed in ducts, trays or on racks or combined in circuits using all three. Such versatility can be important to you.

At Niagara Mohawk's new Albany Station, over 150 miles of Rome power and control cables are installed. Their Dunkirk Station, completed in 1951, also has many miles of Rome products.

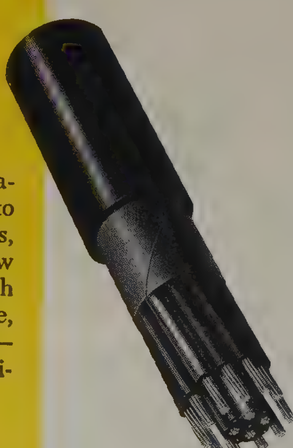
The junction boxes at the Pittsburg plant look like this—neat termination of cables to busses. Miles of Rome copper control cables and Rome aluminum power cables are among the products used here.



Rome Cable engineers *worked with* PG&E and Bechtel Corporation engineers to make sure Rome cable was right for the job and right on the job, as scheduled. This is the kind of service *you* can expect from Rome.

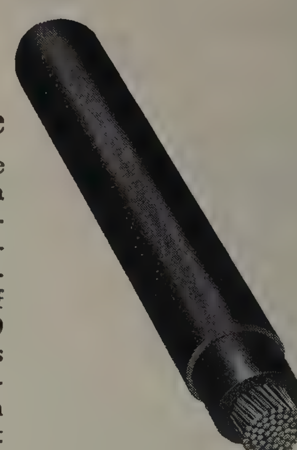
Rome station control cable

RoLene (polyethylene) insulation is virtually impervious to oxidation, oils, most chemicals, water, d-c electro-osmosis, low temperatures. Synthinol sheath is tough, highly resistant to flame, moisture, corrosion, abrasion—has long life under severe conditions.



Rome power cable

RoZone premium quality oil base insulation is resistant to corona action, aging; shows high stability in water; has excellent electrical characteristics; is safeguarded by ionization testing of every foot of cable rated 3000 volts and over. RoZone exceeds all requirements of ASTM specification D-574. RoPrene sheath (Neoprene) protects cable against damage, abrasion, is easy to pull.




CLARK CONTROL
FIRE SAFETY is our business, too!
Dependable CLARK Fire Pump Motor Starters are on guard in thousands of buildings to help prevent disaster like that above. We have been in this business for nearly half a century and have been pioneers in the field.
CLARK Fire Pump Controls are available in non-automatic and combined automatic—non-automatic types. They are approved by Underwriters' Laboratories, Factory Mutual Association and conform to National Fire Protection Association standards. Because of this approval, CLARK Fire Pump Controllers on your systems earn the lowest possible insurance rates.
Engineering service and descriptive literature is available.
The CLARK CONTROLLER Co.
ENGINEERED ELECTRICAL CONTROL
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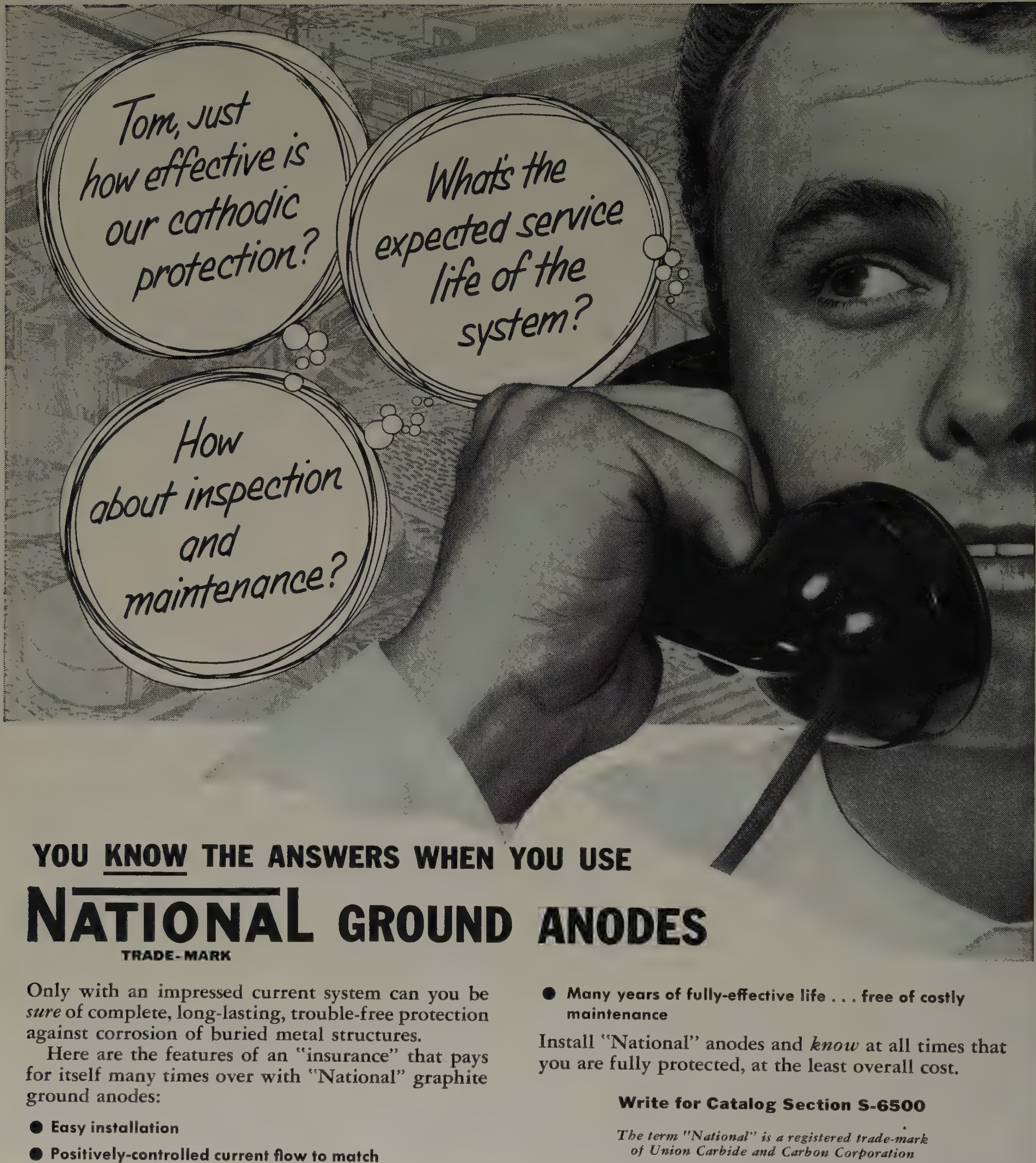
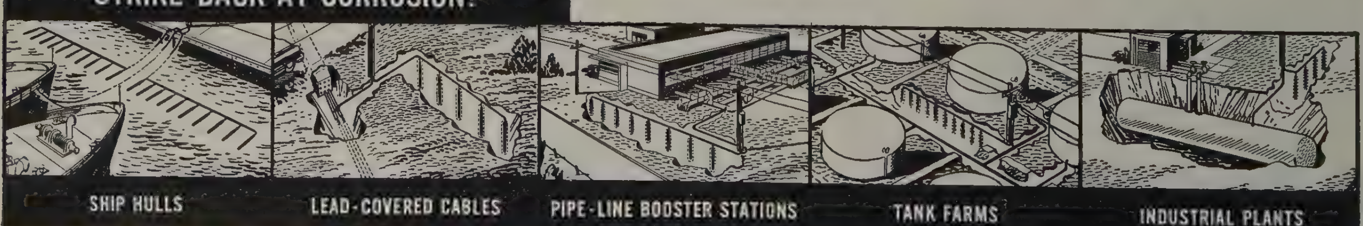
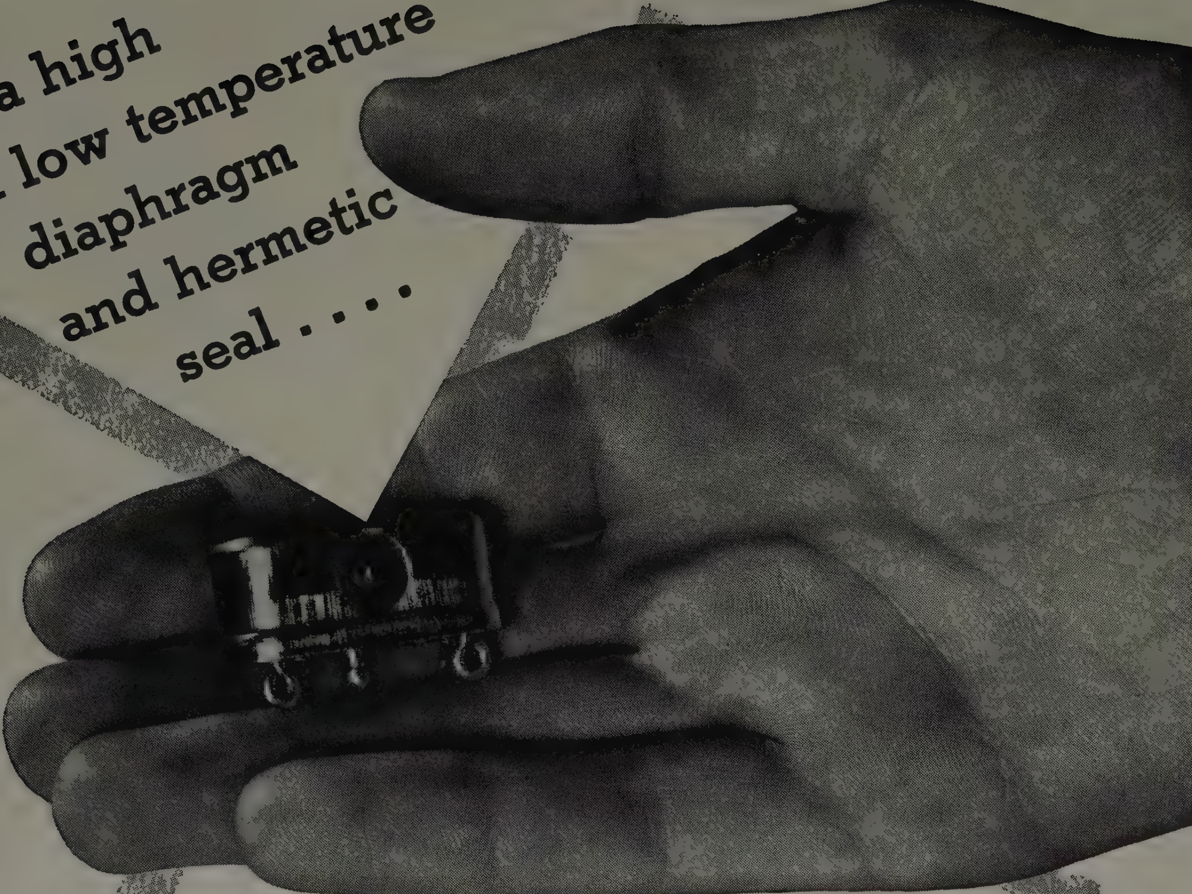


Tom, just how effective is our cathodic protection?
What's the expected service life of the system?
How about inspection and maintenance?



SHIP HULLS
LEAD-COVERED CABLES
PIPE-LINE BOOSTER STATIONS
TANK FARMS
INDUSTRIAL PLANTS

As a high and low temperature diaphragm and hermetic seal . . . .



SILASTIC Stays Elastic

By using a Silastic* diaphragm, Haydon Switch, Inc., of Waterbury, Conn., has produced a hermetically sealed snap-action switch that weighs only about half an ounce and gives maximum life and reliability. It also operates with less than half the effort required by standard "aircraft quality" switches.

The Silastic diaphragm remains so flexible that the operating force on the actuator need not exceed 32 ounces even at —90 F. Fatigue problems and subsequent unreliability associated with metal diaphragms are also eliminated. Operational life in the range of a million cycles is far in excess of the best metal diaphragms or bellows.

Accelerated permeability tests indicate that an effective hermetic seal is maintained for more than 10 years. Internal pressures up to 100 psi have failed to produce leakage or rupture, and no change in the diaphragms has been observed even after 72 hours' immersion in salt, fresh, or soda water, or in automotive or AN-0-6 aircraft oil.

Originally designed for aircraft, fire control and guided missile service, the new miniature switch is being applied to domestic and commercial washing machines, machine tools and other equipment exposed to liquids or moisture.

That's the kind of performance that has established Silastic as an ideal diaphragm material where pressures must be maintained despite temperature extremes, weathering and oxidation, or in contact with a variety of oils and chemicals. Silastic is also unique among resilient dielectric materials because it combines high thermal conductivity with excellent resistance to moisture, corona, and to fatigue.

That's why, if you need a rubberlike material that retains its dielectric properties and its resilience at temperatures from —100 to 500 F. it pays to consider Silastic first.

*T. M. REG. U. S. PAT. OFF.

MAIL COUPON TODAY
for data on the properties, performance and applications of Silastic.

DOW CORNING CORPORATION
Midland, Michigan

first in Silicones

Dow Corning Corporation, Dept. H-18, Midland, Michigan
Please send me:
- ☐ Silastic Facts 10a, properties and applications of Silastic stocks and pastes.
- ☐ List of Silastic Fabricators.
- ☐ "Tall Tales and Fabulous Facts," a 24-page booklet on the properties of Dow Corning Silicones.

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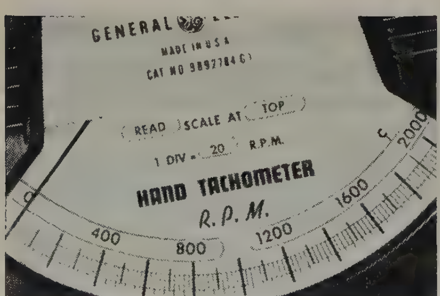
ATLANTA CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D. C. (Silver Spring, Md.)
Canada: Dow Corning Silicones Ltd., Toronto England: Midland Silicones Ltd., London France: St. Gobain, Paris

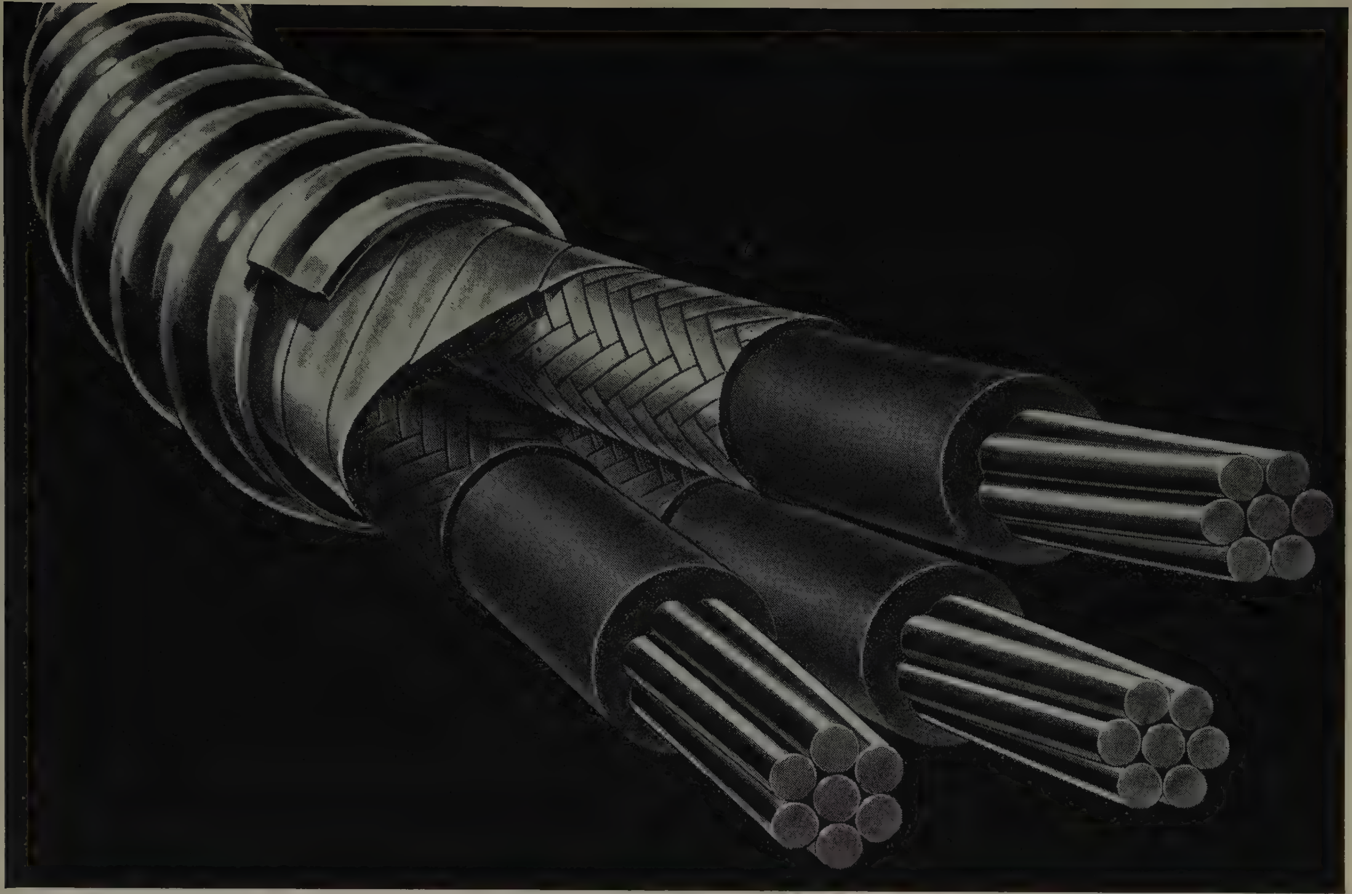
0–2000 SCALE



0–5000 SCALE

0–10,000 SCALE

NEW SCALE-CHANGING FEATURE of G-E hand tachometer eliminates errors that so often occur when reading a scale that has two or three sets of numbers. At any one setting of the control knob, *only one* of three sets of numbers is visible. A simple turn of the knob brings into view the 0–2000, 0–5000, or 0–10,000 scale, as shown above. Other models provide 0–1000, 0–2000, and 0–5000 scales; and 0–200, 0–500, and 0–1000 scales. High- and low-speed adapters increase the range of each of the scales by a factor of 10.



What goes into a G-E Silicone-rubber Cable?

Silicone-rubber insulated cable being subjected to 1400°F flame for 24 hours in laboratory tests. Superior materials and rigid testing go into each G-E cable.

How can G-E silicone-rubber insulated cable keep control circuits in operation—although engulfed in flame? Why can this cable operate at temperatures up to 257°F? What gives it the moisture resistance of the best grades of rubber? In short, what makes it an outstanding cable for vital control circuits, for boiler room installations, and for high-temperature processing operations?

The answers to all these questions are the unique properties of the special silicone-rubber insulation—and each vital property has a history of G-E research, development engineering, and testing. Flame tests at 1400°F proved that this new insulation would remain nonconducting even when completely oxidized. Accelerated-aging tests proved that the cable would dependably withstand continuous ambient or conductor temperatures up to 257°F. Silicone rubber was compounded in many different ways and proportions to produce a cable that would retain its electrical and physical properties through prolonged water-immersion tests—and that could be handled and terminated as easily as an ordinary rubber-insulated cable.

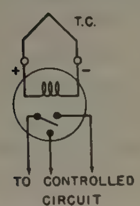
When you specify G-E silicone-rubber insulated cable or any G-E cable you can be sure that the research, knowledge and equipment of the entire General Electric Company have been combined to produce the best possible product. For more information write Section W137-616, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

Progress is our most important product

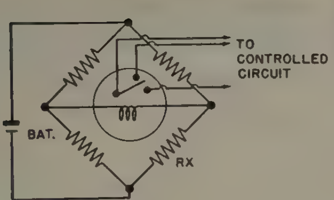
GENERAL ELECTRIC

Wherever *reliable* sensitive control is required

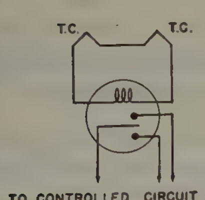
SUGGESTED APPLICATION SCHEMATICS



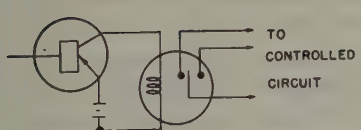
Temperature Control and Protection



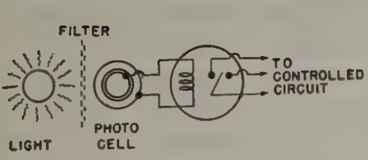
Resistance Selection



Temperature Differential Control



Transitor Selection



Low Level Light Detection and Control

WESTON
Sensitrol Relays

- **eliminate need for involved electronic circuits, and auxiliary power supplies.**
- **operate directly on values low as ½ microampere, or ¼ millivolt.**
- **handle substantial wattage at 110 volts on non-chattering *magnetic* contacts.**
- **available with single or double contacts, fixed or adjustable, manual or solenoid reset.**

Designing, or redesigning, for greater simplicity, compactness or reliability, investigate these widely used, ultrasensitive relays. So sensitive that they operate direct on the output of thermocouples, resistance bulbs or photocells, they enable designers to cut manufacturing and maintenance costs by dispensing with involved circuits and many troublesome components. To help you adapt these rugged relays to your problems, engineering assistance is freely offered. Write . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON *Instruments*

Engineering Societies **Personnel Service, Inc.**

New York 8 West 40th St. | **Chicago** 84 East Randolph St. | **Detroit** 100 Farnsworth Ave. | **San Francisco** 57 Post St.

In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of these advertisements, to pay placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, non-profit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns.

Apply by letter addressed to the key number and mail to New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

MASTER'S DEGREE IN MANAGEMENT, June 1954; 14 yrs des exper; last 6 yrs engrg responsibility for highly complex aircraft mechanism with unit cost of $30,000 and yearly income of $25,000,000. E-761.

ELEC ENGR, B.S. in E.E.; 52, married; 18 yrs responsible pos in opertg, maint, engrg in util and indus; 4½ yrs elec engrg instr college and tech school. Desires elec engrg pwr teaching college, head elec dept tech school or powr engrg. Now employed. E-762.

ELEC ENGR, B.S.E.E.; 31; broad exper hydroelectric constr, generator, turbine erection, service engr switchgear, controls, breakers, starters, motors, transf; 18 mos grad training. Desires pos engrg, maint, constr. E-763-875-Chicago.

ELEC ENGR, B.E.E. Cooper Union 1948, M.E.E. (Power) NYU, 1955; married, 2 children; 4 yrs comprehensive exper all phases of pwr plant, substation and distr line des; 2 yrs transf and mag amp exper. Desires pos of responsibility requiring tech competence and admin ability. E-764.

Positions Available

ELECTRICAL ENGINEER OR PHYSICIST with Master's degree, experienced in electronic instrumentation and circuit design, interest in applications of medical electronics. Participating in expanding research in medical school department. Possibility of advanced degree in either engineering or medical field. Location, Pennsylvania. Y-9629.

ASSISTANT PRODUCTION AND DESIGN ENGINEER, 30–40, with electrical engineering degree and four to five years' experience in the design and development of a complete line of capacitors. Experience in paper capacitors and plastic dielectrics helpful. Will aid in the production and design of high voltage capacitors and pulse forming networks. Will also assist in setting up laboratory programs, working with other engineers and technicians in experimentation. Salary, $6000–$7200 a year. Location, Pennsylvania. Y-9660.

ENGINEERING CONSULTANT, 30–35, electrical engineer, with experience in design, maintenance and/or operation. Any experience in selling or marketing helpful. Responsibilities involved in this work include contact with clients to advise and consult with them in the organization of the information on their manufactured products or services, for presentation in technical catalogs. Previous catalog experience useful, but not necessary. Some travel. Salary open. Travel expenses paid. Headquarters, New York, N. Y. Y-9674.

ELECTRICAL ENGINEER OR PHYSICIST interested in research and development of optical or electromechanical instruments. Should have B.S. or Ph.D. degrees. Physicists with background in nuclear or solid state physics not acceptable. Y-9684.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the first of the month preceding issue; i.e., July first for August issue.

PROJECT ENGINEER, Electronics, M.S. or Ph.D. in Physics with a major in electronics and a working knowledge of optics. Five or more years' experience in development and design of small precision instruments involving electro-magnetic circuits, pulse electronics and some computer work. Experience in graphic arts helpful. Will be responsible for one or more projects involving drafting, development, research, testing, production engineering, materials and model construction. Prepare estimates of new projects, etc. Salary, $8000–$9000 a year. Location, New York Metropolitan Area. Y-9703(a).

ELECTRICAL ENGINEER, 28–30, married, with three or four years' experience in the manufacture of electrical equipment. Should have academic background in the power specialty rather than electronics or communications field. Initial work may be devoted largely to testing, but applicant has opportunity to grow into a senior development engineer on the product with which the company is now engaged. Should also have a good knowledge of mechanical design. The product line includes time delay relays, transformers, airfields lighting equipment, marine aids to navigation and highway reflectors and signs. Salary, about $6000 a year. Location, New Jersey. Y-9813.

CHIEF ENGINEER, 35–45, mechanical or electrical graduate, with at least five years' design, development and application experience covering medical instruments, vibration analyzers and oscillographic equipment. Salary, $10,000 a year. Location, Massachusetts. Y-9848.

PROJECT ENGINEERS for aircraft engine accessory manufacturing company; graduates. (a) Project Engineer with a background of servo theory for dynamic analysis of feedbacks control systems, as applied to turbojet and turboprop engines. Will be required to set up and perform system analysis by use of analogue computer equipment. (b) Project Engineer with a background in fluid mechanics to work on hydraulic control development and fuel systems for turbojet engines. Will be required to execute design and performance analysis for steady state and transient conditions. Location, Connecticut. Y-9903.

ELECTRICAL DESIGN ENGINEER for aircraft electrical systems—A.C. and D.C. generators for motor regulators and protective devices. Must have degree in electrical engineering or have had equivalent in design experience, as work includes basic design calculations. Salary, $8500–$10,000 a year. Location, Canada. Y-9909.

ELECTRONIC ENGINEER, electrical graduate, with at least eight years' experience in UHF and radar systems, to act as group supervisor. Must be citizen. Salary, $9000–$11,000 a year. Location, New York, N.Y. Y-9911.

SENIOR ELECTRONICS ENGINEER with minimum of three to five years' experience in selenium rectifier applications, magnetic amplifiers and power control equipment to develop circuitry and associated components. Salary, $6500 a year. Location, Connecticut. Y-9920.

ELECTRICAL SUPERVISOR, 28–35, with B.S. in mining engineering, and five to eight years' experience in heavy industry, preferably cement and lime. Capable of laying out and supervising installations and maintenance of electrical equipment. Experience with substation equipment and power contracts helpful. Salary, $4800–$6000 a year. Location, West Virginia. Y-9933.

SUPERINTENDENT OF MUNICIPAL UTILITIES, electrical engineer, for a community of about 4,500 people. The electric plant supplies all of the demands of the city. Salary open. Location, Illinois. Y-9940.

ELECTRICAL ENGINEER, not over 40, with at least five years' industrial experience in design, construction or plant operation involving maintenance of electrical equipment applications to power generation, power generation, power distribution, control, motor applications and lighting. Location, Delaware. Y-9952(b).

CHIEF ENGINEER, mechanical, electrical, chemical or civil, with at least five years' experience in responsible supervisory position and preferably in process industries. Knowledge of pulp mill operations and pumps. Duties will include direction of engineering department comprising 6 section heads and their subordinates to support maintenance, design of new production machinery; some coordination of outside vendors; specifications of equipment feeds and output. For a paper manufacturer. Salary, $8500–$10,000 a year. Employer will negotiate fee. Location, Alabama. Y-9987-C-1847.

DESIGNER with electrical engineering training and at least five years' experience in power rectification, to design and estimate selenium rectifiers in heavy power field. Salary, $7000 a year. Location, southern Connecticut. Y-9990.

DESIGN AND APPLICATION ENGINEER, B.S. in electrical engineering, 25–40; three years' experience in design. Knowledge of products using permanent magnets or magnetic circuits. Will do design and application of products to new and improved customer usage. Control of magnetic specifications as related to application. Liaison with manufacturing equipment design. Company manufacturers permanent magnets. Salary, $5196–$6936 a year. Employer will negotiate fee. Location, northern Indiana. C-1827.

ENGINEER who has had some electrical experience; age open; some knowledge of Universal Brush type motors and electric motors in general desirable. Will compute windings for 6 to 220 volt motors and work with same and small fractional hp motors. Salary, to $10,000 a year. Location, Wisconsin. C-1846.

DESIGN ENGINEER, 30–40, mechanical or electrical degree with several years' experience in instrumentation or electrical controls. Will do development and design work on mechanical portion of indicating and recording controllers and miscellaneous electrical control devices. Salary open. Location, Illinois. C-1854.

CLASSIFIED ADVERTISING

For help and situations wanted, $1.50 per line. Sale and purchase of used machinery, etc., $2.00 per line, minimum 5 lines, maximum 30 lines, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y., unless other address is given.

Positions Open

WANTED: ELECTRICAL DESIGN ENGINEER with exceptional ability and successful experience in the design and testing of light duty electrically operated remote controlled oil filled and dry type outdoor switching devices from 120 volts to 15 KV. This is an exceptional opportunity for an engineer capable of producing simple and practical designs for low volume production. Advancement is assured and salary attractive. The position is permanent with an established small manufacturer in Indiana. Give experience, education, references, age, recent photo and salary expected. Box 114.

ELECTRICAL ENGINEER-Graduate, 5 to 10 years' experience, preferably in design and theory of Series, Universal, and D.C. motors. Must be able to take responsibility for complete line of motors after a year or so of training in department. Opportunity for advancement to Management excellent. Salary open. Location, Northeast Ohio. Box 136.

ELECTRICAL ENGINEER for supervisory position in Maintenance Department of large western Pennsylvania chemical plant. Excellent opportunities for advancement. Three to five years' experience desirable. Reply giving age, education, experience, and salary requirement. Address Box 140.

DISTRIBUTION ENGINEERS—Two competent experienced graduate Electrical Engineers, with approximately 10 years experience design, operation and maintenance of distribution facilities in established rapidly growing utility located South America. Reply giving resume education, experience and personal data. Box 149.

METER SUPERINTENDENT—Established rapidly growing utility in Brazil requires competent technician with 10 years experience Meter Department of U.S. or large Latin American Public Utility to supervise Meter Departments several operating companies. Single man preferred as considerable traveling involved. Reply giving resume education, experience and personal data. Box 150.

ELECTRONIC RESEARCH AND DEVELOPMENT positions are available to men with intelligence, imagination, and the desire to produce significant work. Our firm is devoted entirely to research and development, numbers about 1000, and is owned by one of the nation's leading universities. Our salary and benefit programs are competitive with industry. Almost every branch of electronics is covered in our program, and internal funds are available for research on promising individual ideas. Additional information on current

(Continued on page 77A)

(*Continued from page 75A*)

openings will be sent upon request. Cornell Aeronautical Laboratory, Inc., Buffalo 21, New York.

TEACHING POSITIONS for September 1, 1954, are available at a University in the Southeast. Associate Professor, $5,500–$9,400; Instructors, $3,500–$4,300; Graduate Assistants (M.S. in 12 months), $110 per month, tuition free. Box 152.

LOAD DISPATCHER—Established growing utility in one of the most desirable locations in Brazil desires temporary services (about one year) of experienced technician to initiate dispatching service and train local personnel in its operation and maintenance. System is combination thermal and hydro with transmission up to 132 kv. Excellent opportunity for active retired experienced chief load dispatcher. Reply giving education, experience and personal particulars. Box 158.

TRANSFORMER ENGINEER—Must be experienced in designing dry type power transformers and related units. This is an unusual opportunity for a young man to become associated with a well established company which offers financial security and a good opportunity for advancement. Give details covering training and experience in first letter. Box 159.

ELECTRICAL ENGINEER—30–40, with at least 5 years' experience in research, design and development of insulated power cables. Salary open. Location, New York Metropolitan area. Box 160.

PRODUCT ENGINEER—Graduated engineer with utility experience in transmission and distribution desired, for design and quality control with company manufacturing power line connectors, splices and deadends. Will work closely with sales and production departments as well as other engineers. Salary open. RELIABLE ELECTRIC COMPANY, 3145 Carroll Avenue, Chicago 12, Illinois.

ASSISTANT ENGINEER–COMMUNICATIONS. Graduate. 2–5 years' experience desirable. Telephone, carrier, and strong VHF radio experience essential. Microwave experience will be given special consideration. Work on all phases communications for Class I Railroad with headquarters in Midwest. Excellent opportunities for advancement in growing organization. Salary open. Reply giving age, education, experience and salary requirements. Box 161.

Positions Wanted

ELECTRICAL ENGINEER, EE, 38, married. Presently employed. Desires responsible position sales or engineering motors industrial control or allied electromechanical equipment. 15 years experience manufacturing development application and sales. Box 145.

SALES ENGINEER, B.S.E.E., age 29, married. 4 years successful experience in industrial technical sales and administration. Desires challenging assignment in sales or engineering with progressive company. Will locate anywhere. Resume upon request. Box 130.

ELECTRICAL ENGINEER, B.S.E.E., age 33, 6 years' experience in teaching power courses; 2½ years as plant electrical engineer for a minerals processing company. Seeking a position in design, maintenance or production. Box 153.

ELECTRICAL ENGINEER, B.S.E.E., M.S.E.E. One year management training. One year instructor of electronics. 4 years field service airborne electronic equipment. Desire sales, service position. Age 29, Box 154.

ELECTRICAL ENGINEER, B.E.E., Registered P.E., 39, family, 6 years G.E. "Test" and Industrial control engineer, 5 years design and field engineer for elevator manufacturer, 6 years in present position as Vice President in charge Engineering for small control manufacturing company. Desire responsibile position with progressive company. Box 155.

PROFESSOR OF ELECTRICAL ENGINEERING would consider transfer as Department Head or Professor to University offering attractive opportunities and terms. 40 years of age, DSc., 17 years' experience in industry, research and teaching. Teacher of senior and graduate courses in Power Transmission, Power System Studies, Servomechanisms and Applied Mathematics. Numerous publications in leading national engineering magazine. Author of recent advanced engineering book. Registered professional engineer. Member of professional and honorary societies. Box 156.

MANUFACTURER'S AGENT in Philadelphia-Baltimore wants switchgear, transformer, control lines. Box 157.

ELECTRICAL ENGINEER, B.S.E.E., registered P.E., now employed, age 39, family. 7 years' experience in test maintenance, installation of varied power apparatus; control circuits (no electronics). Desire opportunity in design, development of electrical equipment. Will relocate. Box 162.

TRANSFORMER ENGINEER—MSEE, 52, experienced as Chief Engineer, Manufacturing Plant Manager, Designer of medium and large, H.V., Power Transformers to Impulse level. At present with large manufacturer. Desires change of position. Box 163.

Professional Engineering Directory

Professional Engineering Directory Card 1" x 2" 12 times $100.00

INDEX TO ADVERTISERS